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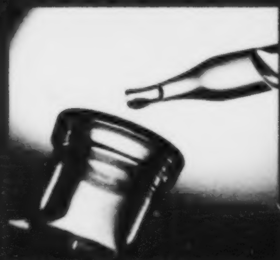
SASKATCHEWAN WATERSHED AUTHORITY

STATE OF THE WATERSHED REPORT

2007 STATE OF THE ENVIRONMENT REPORT



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SASKATCHEWAN WATERSHED AUTHORITY

STATE OF THE WATERSHED REPORT

MARCH 2007

2007 STATE OF THE ENVIRONMENT REPORT

One of our biggest challenges and opportunities in Saskatchewan is how we use, share and enhance watershed resources. In order to achieve this vision, we need to consider, in an integrated way, information on the health of our watersheds.

A crucial step in addressing the protection of source waters across Saskatchewan was made in January 2006 when the *State of the Watershed Reporting Framework* was released. The Framework uses indicators to assess the health of our watersheds and presents that information in an easy to understand and use format.

I am very proud to release the first *State of the Watershed Report* based on the Framework. This report will be used as an important management and evaluation tool for assessing watershed health and will provide the people of Saskatchewan with a far more complete picture of the province's watersheds than has ever been available before.

The *State of the Watershed Report* supports Saskatchewan's Green Strategy by further enabling government, business and the community to work together to ensure a green and prosperous future for our province that is in balance with our social and economic priorities.

In addition, the *State of the Watershed Report* doubles as the 2007 *State of the Environment Report*, satisfying the conditions set out in *The State of the Environment Act* to report on the 'current condition of the environment in Saskatchewan and the relationship between the condition of the environment and the economy of Saskatchewan.'

In future years, *The State of the Environment Report* will include both environmental and socio-economic indicators and will serve as the provincial sustainability report supporting the Green Strategy.

Every one of us has a role to play in protecting watershed resources. Success will require increased awareness of the overall health of watersheds. Together, we will further our understanding of the challenges faced by Saskatchewan's watersheds, in order to protect this precious resource today and for future generations.

The Honourable John T. Nilson, Q.C.

EXECUTIVE SUMMARY

Why a *State of the Watershed Report*?

Saskatchewan's *State of the Watershed Report* is a benchmark tool for assessing watershed health to ensure source water protection and sufficient water supplies in Saskatchewan. The framework for this report is specifically designed to allow watershed health comparisons to be made among watersheds and within watersheds over time. This reporting system will provide a basis for governments, decision-makers, industry and the community to act in the long-term interest of environmental sustainability.

Effective environmental policies, decision-making and management of our watersheds requires relevant, accessible, timely, understandable and scientifically-defensible information. To date, most data required for decision support have not been systematically converted into information. To address this critical gap, the Saskatchewan Watershed Authority adopted State of the Watershed Reporting. This reporting process is based on the Stress-Condition-Response model and uses indictor-based assessment ratings for environmental stressors, watershed health and management responses. Individual indicators were given a rating to differentiate the relative stressors, conditions and responses among watersheds. This rating system is designed for the regular reporting on watershed health and allows for the assessment of changes among watersheds and within watersheds over time.

Condition indicators assess the health of Saskatchewan's watersheds by quantifying critical aspects of water quality and measurements of water quantity and riparian and rangeland health. Stressor indicators assess issues related to population, water use, agriculture, and industry. Response indicators include conservation efforts, education, stewardship, and planning and policy. Indicators were calculated using a Geographic Information Systems (GIS)-based platform enabling the integration of spatially diverse data sources, while providing easy-to-understand indicator maps as the end product.

Objectives

The key objectives of State of the Watershed Reporting are:

- to assess the health of watersheds in Saskatchewan;
- to identify the relative potential stress of human activities on watersheds in Saskatchewan;
- to recognize the management responses that have been implemented; and
- to communicate this information to the public and resource managers for decision-making purposes.

How to Read the Ratings

Condition

The health (condition) of Saskatchewan's watersheds can be affected by the lifestyle and activities of humans. To assess the health of watersheds in Saskatchewan, seven condition indicators were developed. Each of the condition indicators have rating schemes that allow for comparative assessments of watershed health. The health of Saskatchewan's Watersheds was categorized into one of three classes: healthy, stressed or impaired. All condition indicators were weighted equally to provide the means to assess overall watershed health. The health of a watershed was determined using a methodology, where the overall health of the watershed is based on the lowest health rating of all seven condition indicators. Therefore, a watershed is rated as impaired if at least one of the seven condition indicators had a rating of impaired; stressed if the lowest rating for at least one of the seven condition indicators had a rating of stressed; or as healthy if all of the seven condition indicators had a rating of healthy.

Based on this assessment, six of Saskatchewan's watersheds were identified as being comparatively healthy, eleven watersheds were identified as stressed, and twelve watersheds were identified as impaired (Figure 1).

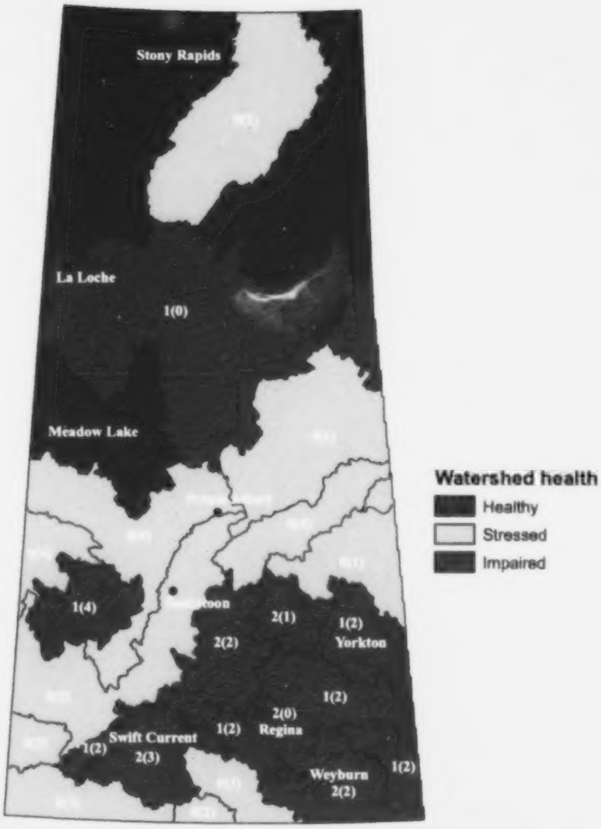

Figure 1. Health of watersheds based on condition indicators.

Note: numbers within the watershed boundaries represent the number of condition indicators that are either impaired or stressed. For example, in the Assiniboine River Watershed there is one impaired condition indicator and two stressed condition indicators, 1(2).

Stressors

Broad categories of human activities with the potential to stress the health of watersheds include human settlements (e.g. cities, towns, and municipalities and associated infrastructure), water use, agricultural land use, and industrial land use.

To assess the potential stress of these activities on watersheds in Saskatchewan, 19 stressor indicators were developed. Each of the stressor indicators have rating schemes that allow stress to be rated by watershed. Each stressor on Saskatchewan's watersheds was categorized into one of three classes: low stress, moderate stress or high stress. All stressor indicators were weighted equally to provide means of assessing the overall stress on each watershed. The following rating scheme was applied to each watershed:

- Low stress – less than 3 out of the 19 stressor indicators have a high stress rating.
- Moderate stress – between 3 and 5 out of the 19 stressor indicators have a high stress rating.
- High stress – more than 5 out of the 19 stressor indicators have a high stress rating.

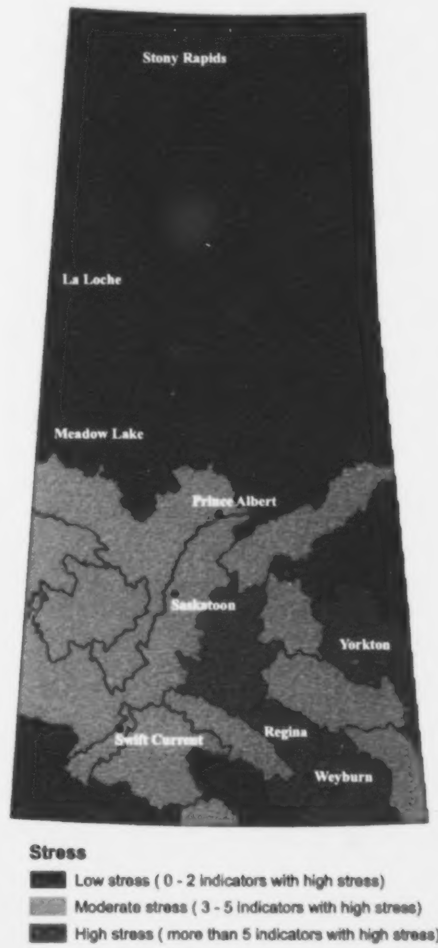

Figure 2. Stress rating by watershed.

Based on the ratings for the 19 stressor indicators, four watersheds have a high stress potential rating, 12 watersheds have a moderate stress potential rating and 13 watersheds have a low stress potential rating (Figure 2).

Responses

Ten response indicators have been developed to provide information on management decisions that have been made to mitigate the stresses and improve the health of Saskatchewan's watersheds. Five of the ten response indicators have insufficient data to rate the management responses within or between watersheds. This is because organizations typically collect management response information on a province-wide scale, preventing the summarization of information by watershed. The five indicators that have sufficient data to rate the management responses by watershed include conservation stewards, watershed and land use planning, water quality monitoring and management, water quantity monitoring and management, and protected areas indicators.

Of the 29 watersheds, three have a low response rating, 9 have a moderate response rating and 17 have a high response rating. The watersheds with the lowest response rate include the Big Muddy Creek, Eagle Creek, and Kasba Lake Watersheds.

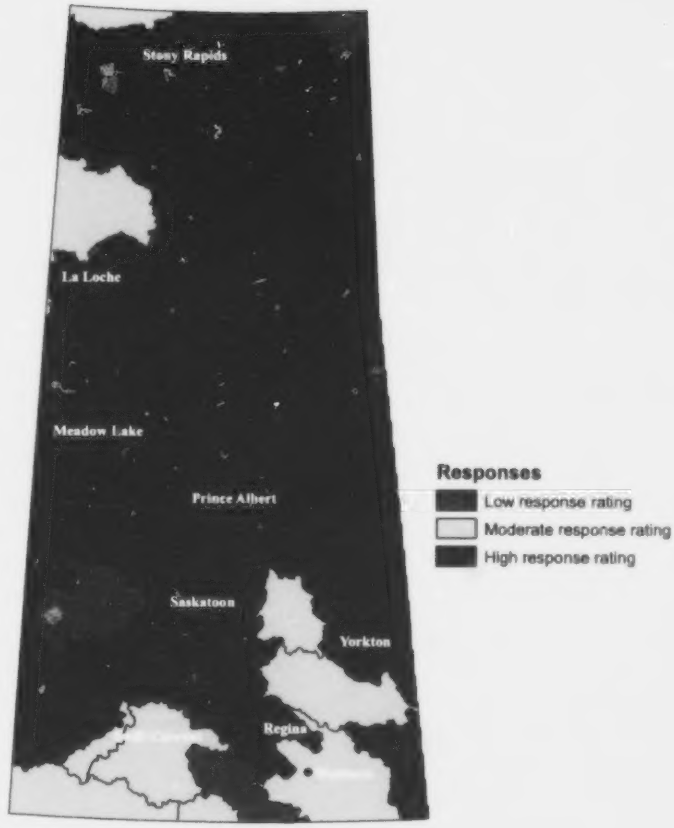

Figure 3. Response rating by watershed.

Looking Ahead

Over the next few years, the Saskatchewan Watershed Authority will work to:

- improve the collection of environmental data in Saskatchewan so that data are collected in a consistent manner and addresses some of the data quality/caveat issues outlined in the *State of the Watershed Report*;
- continue to refine the indicators and the ranking framework based on expert opinion and feedback;
- continue to develop educational programs and tools to engage communities and increase their awareness of, and response to, environmental issues; and
- publish the *State of the Watershed Report* on a three-year basis to gauge change in the indicators and the watersheds.

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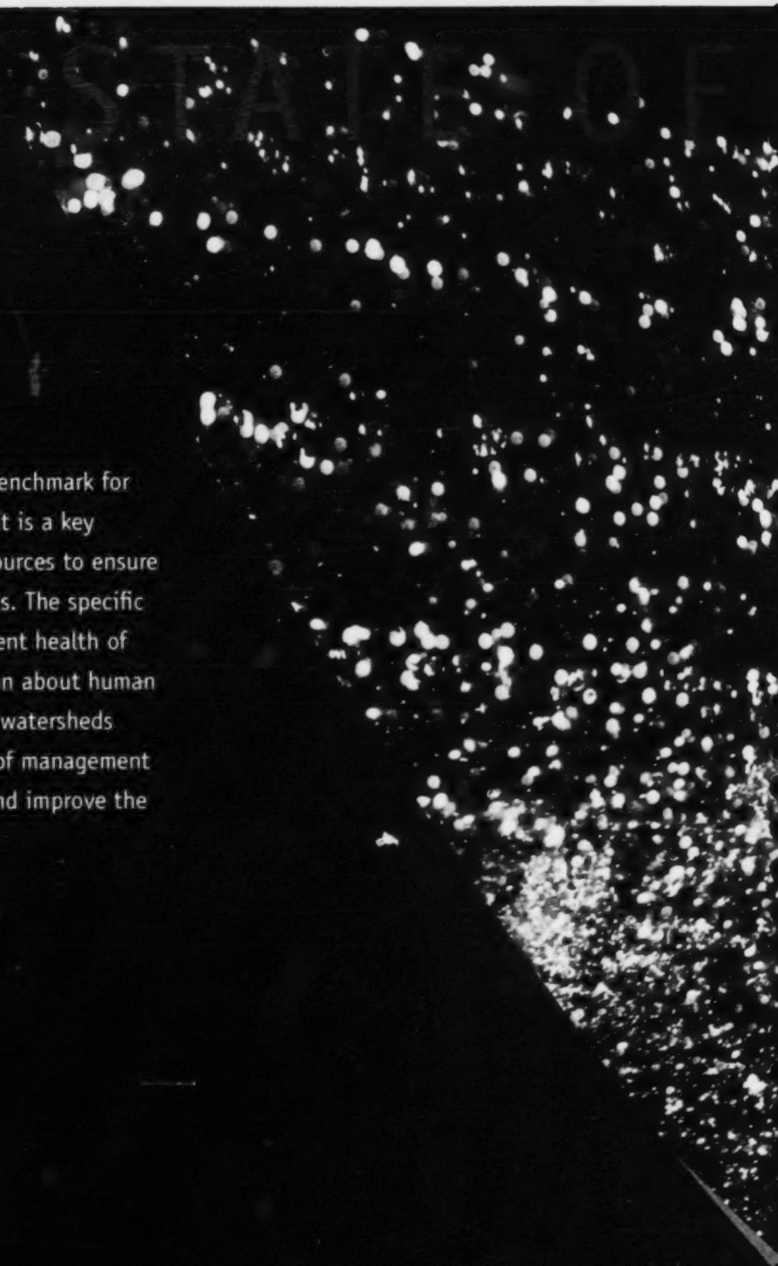

INTRODUCTION

The *State of the Watershed Report* provides a benchmark for assessing watershed health in Saskatchewan. It is a key management tool for protecting our water resources to ensure high water quality and sufficient water supplies. The specific objectives of this report are to assess the current health of watersheds (conditions), to provide information about human activities that impact the environment within watersheds (stressors), and to evaluate the effectiveness of management activities designed to mitigate the stressors and improve the condition of the watersheds (responses).

THE WATERSHED

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The format and content of this report are a reflection of the target audience. Various audiences desire different levels of information, ranging from technically detailed to general summaries. The target audience for the *State of the Watershed Report* spans this range and includes:

- the Saskatchewan Watershed Authority;
- provincial and federal government departments;
- researchers;
- municipalities;
- industry;
- interest groups; and
- the general public.

The format and content of this report was guided by experts within the Saskatchewan Watershed Authority and by an external technical review panel from several government and non-government organizations, including Saskatchewan Environment, Saskatchewan Agriculture and Food, Saskatchewan Industry and Resources, Environment Canada, and Ducks Unlimited Canada.

The *State of the Watershed Report* is based on information available from both within the Saskatchewan Watershed Authority and from other government and non-government organizations. The range of data and the data sources have enabled the production of a comprehensive report containing the most up-to-date information available.

The *State of the Watershed Report* is an indicator-based assessment with a rating system for each indicator. Data were assessed against rating schemes and, using Geographical Information Systems (GIS)-based technology, easy-to-understand maps were produced highlighting the stressors and conditions of Saskatchewan's watersheds. The rating system allows for regular reporting on watershed conditions to assess changes in watershed health and the principal issues that have the potential to affect the health of the watershed. Therefore, the framework for this report is specifically designed to allow watershed health comparisons to be made among watersheds and within watersheds over time. This reporting system will provide a basis for governments, decision-makers and the community to act in the long-term interest of environmental sustainability.

STATE OF THE WATERSHED REPORTING – WATERSHED REPORT CARD

The watershed report card communicates an evaluation of the health of watersheds in Saskatchewan. It consists of a number of essential attributes; specifically, it:

- *is based on a model of a watershed that explicitly recognizes relationships between the health of the watershed (condition), impacts on the watershed, human activities (stressors), and associated management activities (responses). It reflects how we look at the watershed (structure and function) in the context of the goals;*
- *assesses progress in an integrated manner towards the provincial government's water management goals and Saskatchewan Watershed Authority's corporate, program and planning/operational goals, being both relevant and decision-supportive for all target audiences;*
- *provides a context for the development of indicators and associated monitoring plans in a practical, achievable and affordable manner; and*
- *provides a logical rating system to assess stressors, watershed health and responses.*

The watershed report card: *is based on a model of a watershed that explicitly recognizes relationships between the health of the watershed (condition), impacts on the ecosystem, human activities (stressors), and associated management activities (responses). It should also reflect how we look at watersheds (structure and function) in the context of source protection.*

A conceptual model of watershed function is necessary to effectively relate human activity with ecosystem health. The premise behind such a model is that a human activity can impose a *stress* that may impact the *condition* of the watershed, which requires a management *response* to counteract the stress. The *Stress-Condition-Response* Model is presented in Figure 4.

In addition to providing a template on which to base watershed monitoring, assessment and reporting, the *Stress-Condition-Response* Model:

- links stress, due to specific activities, with watershed responses, forming the basis for watershed planning;
- links management activities and monitoring to provide a more comprehensive approach to watershed management;
- relates all aspects of watershed monitoring (i.e. stresses lead to changes in watershed condition and responses aim to relieve stresses and improve condition);
- identifies data gaps and areas where future resources and effort should be focused, including increased understanding of critical thresholds at which ecosystems become impaired and their ability to function is lost; and
- provides a context for the development of indices/indicators to characterize risks, watershed conditions or management issues in a meaningful way for users.

The watershed report card: *assesses progress in an integrated manner toward the Saskatchewan Watershed Authority's corporate, program and planning/operational goals, being both relevant and decision-supportive for all target audiences.*

The impetus of watershed reporting is to assess and measure progress from an overall government view, both from a corporate perspective and on the planning level for the major watersheds within the province.

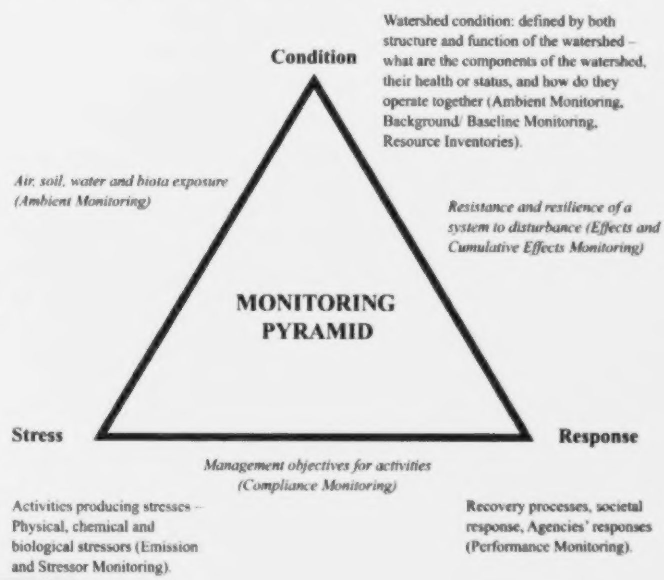


Figure 4. *Stress-Condition-Response* Model demonstrating the relationship between various watershed health components.

Objective one of Saskatchewan's Water Management Framework, 1999, is to "maintain, restore and protect the health of aquatic and riparian ecosystems and drinking water sources." This objective inherently implies the need to understand the status of watershed health to develop effective management and protection strategies. Key actions under this objective include:

- develop indicators and monitor the health of drinking water sources and aquatic ecosystems; and
- establish criteria for rating aquatic ecosystem integrity that can be used to improve decision making.

There are two objectives in Saskatchewan's Safe Drinking Water Strategy that directly tie in with State of the Watershed Reporting:

- risks (stressors) to source water quality are known; and
- citizens have meaningful access to information about the quality of their water.

The Saskatchewan Watershed Authority's Strategic Plan states, under Goal 2 (Healthy Watersheds), that the Authority will "regularly evaluate the health of the watersheds." This evaluation needs to be tied to the other stated goals and objectives in the Strategic Plan. These goals and objectives provide the focus, direction and management priorities under which the Saskatchewan Watershed Authority will develop and implement watershed reporting. The relevant objectives of reporting are to ensure that:

- watersheds are protected, natural purification and protection processes are maximized and the potential for contamination is minimized;
- a safe and sustainable water supply is maintained;
- water management infrastructure is safe and effective; and
- there is sound knowledge of the quality, quantity and distribution of water supplies.

The *Stress-Condition-Response* Model is used to describe the present status of the objectives listed above and is used as a point of discussion on the response aspect of the model. The description will include:

- water quality;
- water quantity and flows– surface and groundwater;
- vegetation – riparian and wetland areas;
- aquatic life;
- soils;
- climate;
- infrastructure – dams, control structures, treatment plants, transportation corridors;
- land cover and use;
- population demographics; and
- water use and allocation.

The watershed report card: ***provides a context for the development of indicators and associated monitoring plans in a practical, achievable and affordable manner.***

Indicators are the tools of the *State of the Watershed Report*. They characterize the issues in a meaningful way. Indicators are a reflection of the environmental and resource management questions, whether those questions relate to ecosystem health, department progress or specific regional concerns. They may be quantitative, descriptive, projective or predictive in nature. Indicators may include information from a combination of several variables. They allow more simplified analysis of complex ecological functions.

The goal of using indicators and indices is to effectively summarize and communicate the status of complex ecological systems into a form that is appropriate for water management applications and public understanding. For State of the Watershed Reporting, the Saskatchewan Watershed Authority is using a series of indicators in the context of the *Stress-Condition-Response* Model. The indicators have a number of key features, including:

- they quantify information such that its importance is more apparent;
- they use existing information;
- they simplify information from complex ecosystems to improve communication with the public and with decision-makers;
- they are a cost-effective and representative alternative to monitoring infinite individual processes; and
- they can be implemented and updated in an appropriate time frame for the State of the Watershed Reporting.

The watershed report card: ***provides a logical rating system to assess stressors, watershed health and responses.***

A review of the scientific literature was conducted to find logical and appropriate rating schemes for the stressor, condition and response indicators. When insufficient data from appropriate scientific studies existed to rate stress or condition indicators, the Jenks' optimization method was used to find the natural breaks in the data. This method minimizes the squared variation of the means within the class, while maximizing the squared variation between the classes. The results of the Jenks' optimization method may change as more data are included. This rating scheme is intended to be used to compare all watersheds within Saskatchewan. A low stress rating simply means that the watershed scored lower relative to other watersheds in Saskatchewan based on the criteria being rated. The ratings given are a reflection of the existing conditions within the watershed and are not an indication of the effectiveness of the response indicators.

Based on the above assessment methods, the following rating schemes were used:

Condition indicators were classified into three classes - Healthy, Stressed and Impaired.

- The condition indicator is shown as green on the Saskatchewan watershed map when the condition of the watershed is healthy; orange when the watershed is stressed; red when the watershed is impaired; and white if there is a data gap or the data are not applicable for that watershed.

Stressor indicators were classified into three classes - Low, Moderate and High stress.

- The stressor indicator is shown as green on the Saskatchewan watershed map when the stress is low; orange when the stress is moderate; red when the stress is high; and white if there is a data gap or the data are not applicable for that watershed.

The stressor rating does not reflect the health of a watershed. The existence of a stress does not mean that the health of the watershed is impacted; it implies that there is a potential for it to be impacted. Stress levels are all relative; therefore, a low stress rating implies that, relative to other watersheds, the potential stress is lower.

Response indicators were classified as Present or Absent.

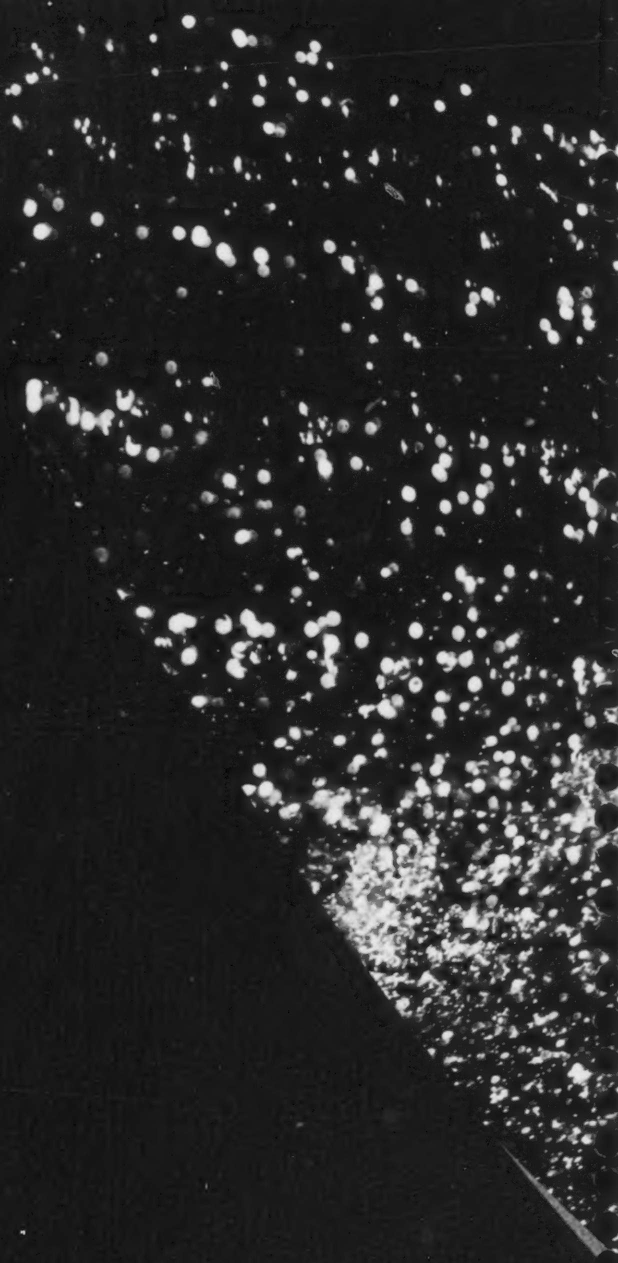
- The response indicator is shown as green on the Saskatchewan watershed map when there is an appropriate response to mitigate the stress and improve the condition, and red if there is no appropriate response.

Indicators of watershed health are grouped into the *Stress-Condition-Response* Model. The stressor section outlines how the resources in the watershed are used and summarizes the magnitude and trend of the major parameters influencing the condition. The condition section indicates the impacts of stressors on watershed health and the capacity of the watershed to buffer those stressors. The response section outlines the management decisions that have been made to address source water protection and watershed health. The intent of the *State of the Watershed Report* is to link watershed management activities by organizations such as the provincial government, municipalities, and stewardship groups with the stressors and conditions of the watersheds.

Table 1. *Stress-Condition-Response* indicators and how they relate.

Issue	Condition Indicators	Stressor Indicators	Response Indicators
Human settlements	- Water quality - Surface water quantity - Groundwater quantity - Riparian health - Riparian buffer - Permanent cover - Species at risk	- Human populations - Roads - Aquatic fragmentation - Potential spring runoff from urban impervious areas - Municipal wastewater effluent discharge - Landfills - Contaminated sites - Industrial waste - Invasive exotic species	- Water conservation - Watershed education - Conservation stewards - Stewardship workshops - Watershed and land use planning - Water quality monitoring and management - Water quantity monitoring and management - Protected areas - Legislative tools, strategies, policies and guidelines
Water use	- Water quality - Surface water quantity - Groundwater quantity	- Surface water allocation - Groundwater allocation	- Water conservation - Watershed education - Watershed and land use planning - Water quality monitoring and management - Water quantity monitoring and management - Protected areas - Legislative tools, strategies, policies and guidelines
Agricultural land use	- Water quality - Surface water quantity - Groundwater quantity - Riparian health - Riparian buffer - Rangeland health - Permanent cover - Species at risk	- Livestock - Soil erosion - Fertilizer inputs - Pesticide inputs - Manure application - Invasive exotic species	- Water conservation - Watershed education - Conservation stewards - Stewardship workshops - Watershed and land use planning - Water quality monitoring and management - Water quantity monitoring and management - Protected areas - Legislative tools, strategies, policies and guidelines
Industrial land use	- Water quality - Surface water quantity - Groundwater quantity - Riparian health - Riparian buffer - Rangeland health - Permanent cover - Species at risk - Environmental acid deposition	- Oil & gas spills - Mining - Forestry - Invasive exotic species	- Water conservation - Watershed education - Watershed and land use planning - Water quality monitoring and management - Water quantity monitoring and management - Protected areas - Legislative tools, strategies, policies and guidelines

DEVELOPMENT OF INDICATORS



What defines an indicator?

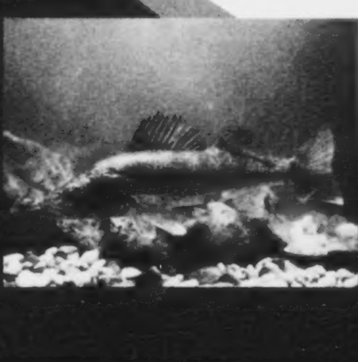
Watershed health indicators provide us with a picture of a watershed's condition and/or the direction of the condition (e.g. whether the condition is getting better or worse). Indicators assist in an overall comprehension of more complex ecosystem processes that occur in the watershed but are difficult to measure. Indicators can show trends, measure progress, and identify problems; however, they are not designed to provide mechanistic explanations or allow conclusions to be made about cause-and-effect relationships.



How were the indicators selected?

A compilation of indicators were proposed by various organizations, including, but not limited to: Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Association, Environment Canada, Saskatchewan Environment, Saskatchewan Industry and Resources, Saskatchewan Agriculture and Food, and Ducks Unlimited Canada. To select the best indicators, a criteria for good indicators was identified based in part on the criteria used in the United States Environmental Protection Agency's Index of Watershed Indicators (2002). The following criteria were used to finalize indicators for this report:

1. **Assess watershed health:** Indicators must characterize some phenomenon important to watershed health, whether it is a stressor/ vulnerability, condition, or agency response.
2. **Educational:** Indicators must present this assessment in a simple, understandable way that will inspire readers to learn more about watershed health.
3. **Measure progress:** Indicators must measure progress toward the people of Saskatchewan's vision of a safe, sustainable water supply in healthy and diverse aquatic ecosystems. The indicator must be able to incorporate long-term changes in watershed health.
4. **Guide more effective resource management:** Indicators must provide meaningful feedback and general direction to water resource management agencies and stakeholders on priorities and mechanisms for effectively achieving healthier watersheds.
5. **Cost effective:** Maximize data sharing and use of existing information, while still offering an effective assessment of watershed health.
6. **Watershed scale:** The scale at which the indicator is presented must match the scale of the phenomenon being measured.
7. **Comparable:** Must be able to compare with historic conditions and standards within a watershed, while also allowing for comparison among watersheds.



Only selecting indicators that could be estimated from currently available, complete datasets would facilitate reporting, but would report on a limited number of indicators. In order for the *State of the Watershed Report* to capture meaningful aspects of watershed health, it must make use of incomplete datasets of variable quality. Indicators cannot be constructed without data, so the majority of the indicators presented below are based on sufficient data for presenting a broad-scale picture of watershed health.

Universally applicable indicators would likewise facilitate standardized reporting, which has a certain appeal. However, the most meaningful indicators will reflect local and regional ecological realities, and therefore be regionally specific.

Limitations

The intention of each indicator is to be representative so that areas at higher relative risk can be identified and the nature of that risk assessed. The methods used to calculate the stressor and condition indicators have several limitations, including:

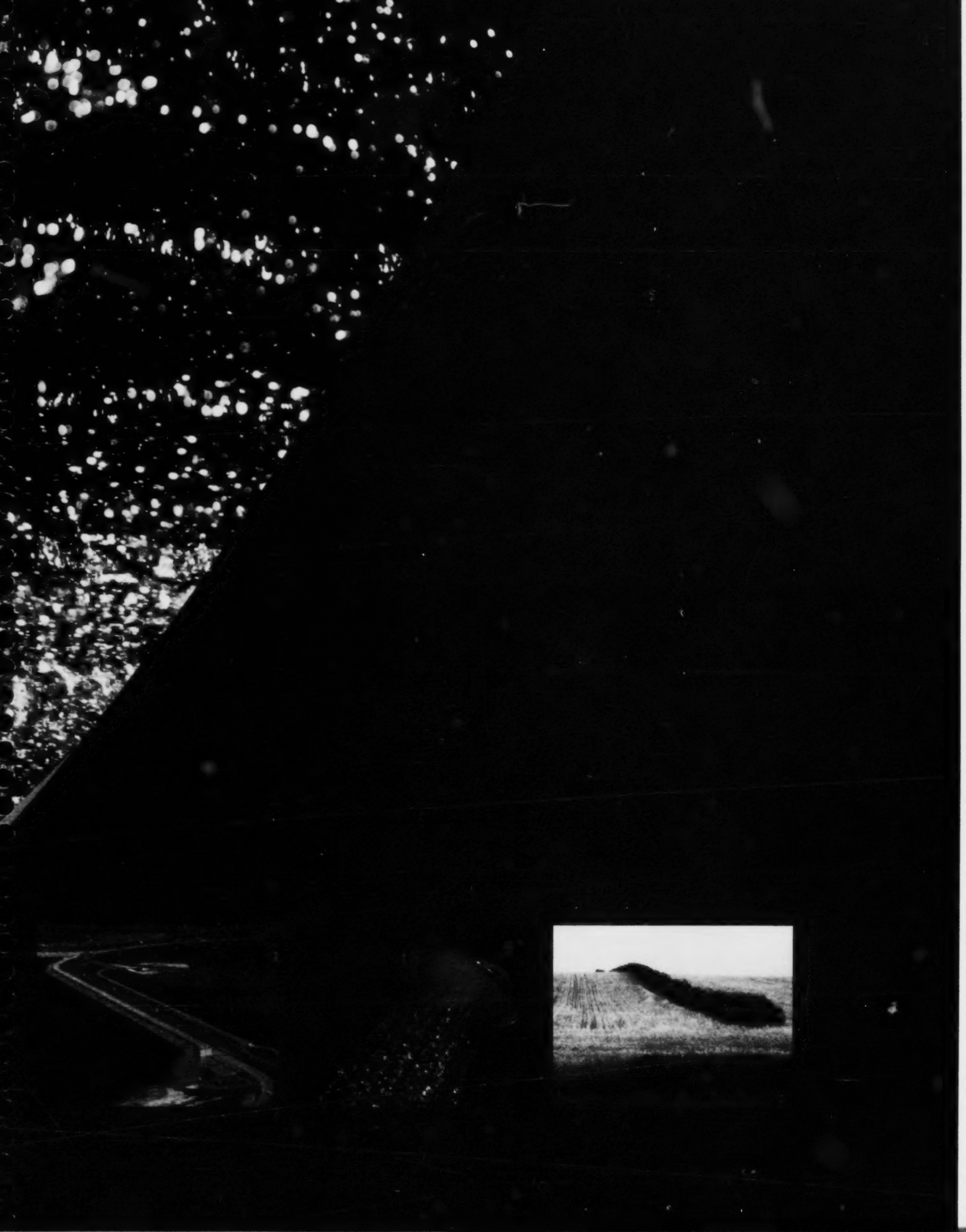
- The indicators are estimates, and they should be thought of accordingly.
- The Jenks' optimization method was used to rate stressor and condition indicators when insufficient data from appropriate scientific studies existed to rate the indicator.

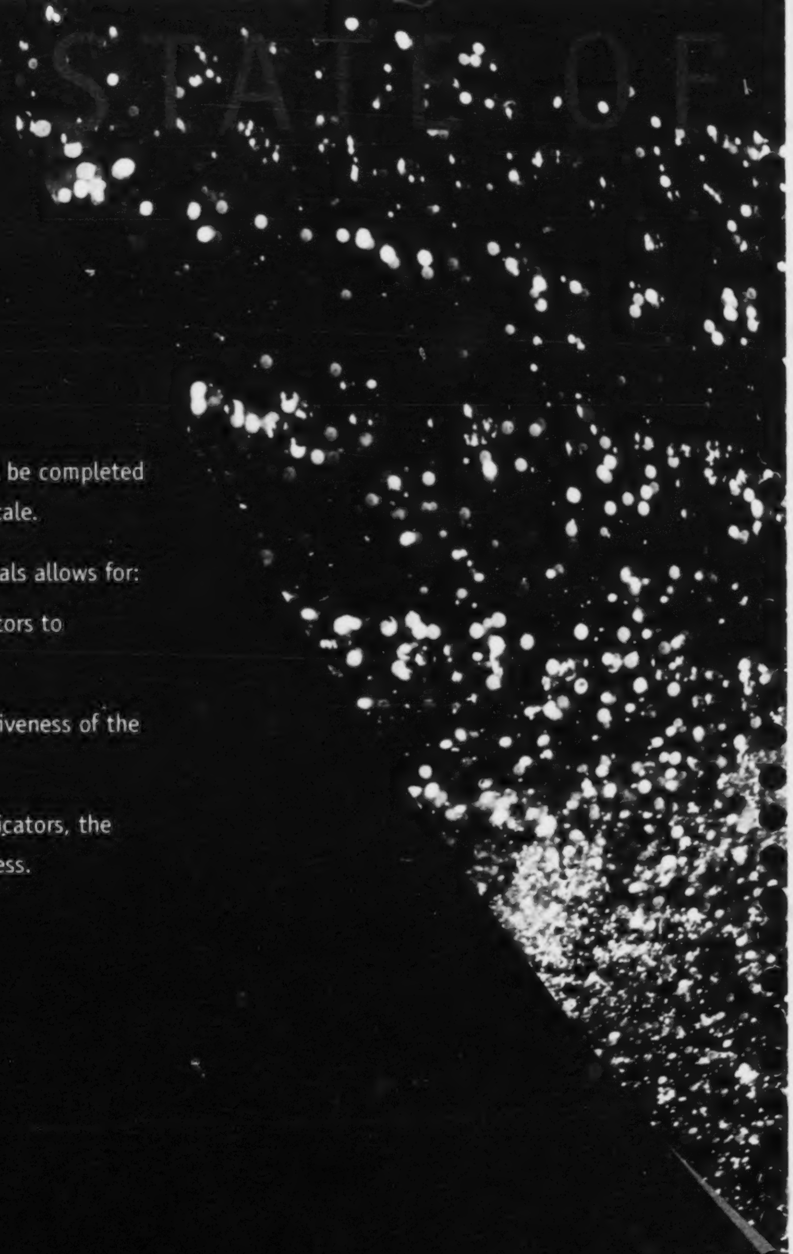
- This rating scheme is intended to be used to compare all watersheds within Saskatchewan. A low stress rating simply means that the watershed scored lower relative to other watersheds in Saskatchewan based on the criteria being rated.
- The natural breaks (ratings) of the Jenks' optimization method may change as more data are included.

***The stress rating does not reflect the health of a watershed.* The existence of a stressor does not mean that the health of the watershed is impacted; it implies that there is a potential for it to be impacted. Stress ratings are relative measures and are designed to provide information on the potential stress levels of the activity in the watershed, relative to other watersheds in the province.**

Development of Additional Indicators

The development of indicators is a dynamic process. The Saskatchewan Watershed Authority will continue to develop indicators to assist in its efforts to manage and protect source water.





TIMING OF REPORTING

Subsequent State of the Watershed Reports will be completed every three years at the provincial watershed scale.

Reporting at a provincial scale at regular intervals allows for:

- trends in the stressor and condition indicators to be assessed;
- assessments to be conducted on the effectiveness of the responses; and
- further development and refinement of indicators, the ranking framework, and the reporting process.

THE WATERSHED

4.0

STATE OF

WATERSHEDS IN SASKATCHEWAN

Background

> *"Saskatchewan is a tapestry made from a material drenched in water."*
>
> Terry Hanley, PhD
> Director, Watershed Monitoring and Assessment
> Saskatchewan Watershed Authority

12% of the surface of Saskatchewan is covered by water. We have more prairie wetlands than any of the other prairie provinces combined. And we have comparable groundwater resources to any Canadian province.

THE WATERSHED

5.0

A watershed or drainage basin is a region that drains into a specific body of water, such as a river, lake, pond, or ocean. It includes all the land, air, plants and animals within its borders. Each watershed has a unique mixture of land and water habitats: from wetlands, rivers and lakes to forests, grasslands, farms, towns and cities. Land forms such as hills or heights of land largely determine the boundaries of watersheds and direct the speed and path of its rivers. Watersheds within Saskatchewan ultimately drain into one of three marine water bodies: the Arctic Ocean, Hudson Bay, or the Gulf of Mexico (Figure 5).

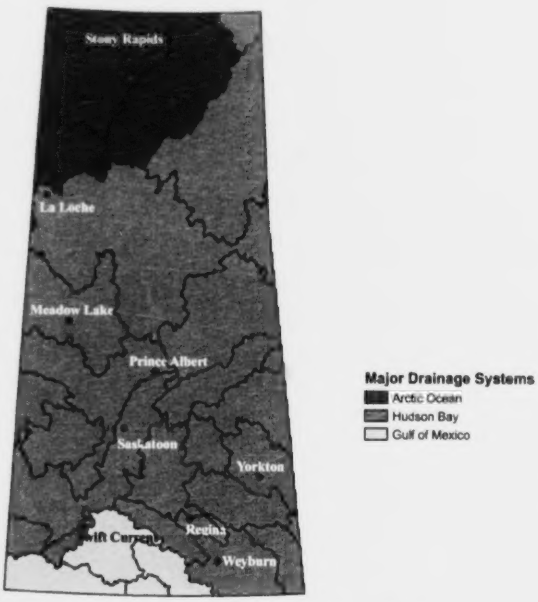


Figure 5. Saskatchewan's three major drainage systems.

Saskatchewan has 14 major watersheds ranging from the tiny Tazin River and Kasba Lake Basins in the north to the immense Saskatchewan River Basin in central Saskatchewan to the Souris River Basin in the southeastern part of the province. For management purposes the Saskatchewan Watershed Authority has divided these fourteen major watersheds into twenty-nine smaller watersheds (Figure 6).

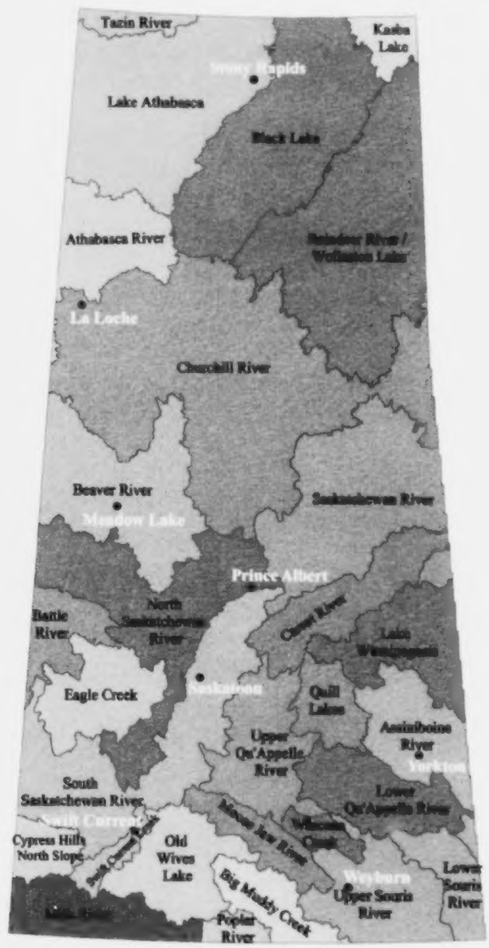


Figure 6. Saskatchewan Watershed Authority's twenty-nine watersheds.

A watershed or drainage basin is a region that drains into a specific body of water, such as a river, lake, pond, or ocean. It includes all the land, air, plants and animals within its borders. Each watershed has a unique mixture of land and water habitats from wetlands, rivers and lakes to forests, grasslands, farms, towns and cities. Landforms such as hills or heights of land largely determine the boundaries of watersheds and direct the speed and path of its rivers. Watersheds within Saskatchewan ultimately drain into one of three major water bodies: the Arctic Ocean, Hudson Bay, or the Gulf of Mexico (Figure 5).

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Figure 6. Saskatchewan Watershed Authority's twenty-nine watersheds.

Surface Water in Saskatchewan

Surface water in Saskatchewan can be classified according to flow (e.g. rivers, lakes), state (e.g. streams, rivers), permanency (e.g. perennial stream, ephemeral stream), productivity (e.g. nutrient poor, nutrient rich) and salinity (e.g. freshwater, saline). These water bodies formed as a result of historic geological processes and localized geologic properties. Within different regions of Saskatchewan the varied geologic properties continue to have a major influence on water quality. This results in strong regional coherence that explains much of the diversity among water body types and water quality properties within Saskatchewan.

As previously noted, the portion of Saskatchewan's surface area covered by water is approximately [illegible]. However, surface waters are not distributed evenly throughout the province. Northern Saskatchewan has a greater proportion of water including some of the largest lakes in Canada, while parts of southern Saskatchewan have very little surface water. A greater proportion of surface water is permanent in the north, whereas many smaller southern wetlands, potholes, streams and creeks do not have water in them year round (i.e. they are intermittent or ephemeral). The amount of surface water, whether it be lake volume or stream flow, is a function of the balance between precipitation, evaporation, transpiration (evaporation from plants), interactions with soil moisture storage and groundwater, and inflow and outflow. The timing of precipitation also affects flow regimes and lake levels. Northern Saskatchewan has greater precipitation (Figure 7) and little infiltration to groundwater. In southern Saskatchewan the volume of water during spring melt is a critical determinant of river flow, lake level and groundwater recharge. In southern Saskatchewan there is a strong connection between surficial groundwater and summertime river flow, lake level and wetland water level.

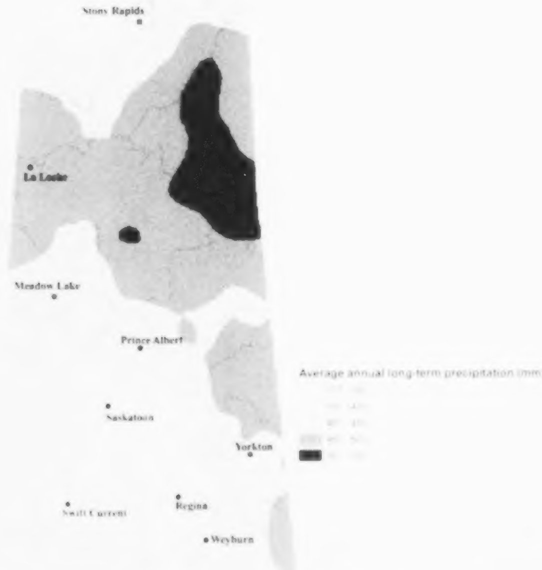
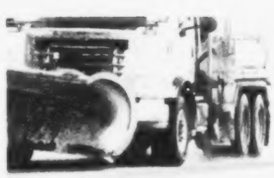


Figure 7. Average annual long-term precipitation in Saskatchewan between 1961 and 1990 (Hopkinson 2000).

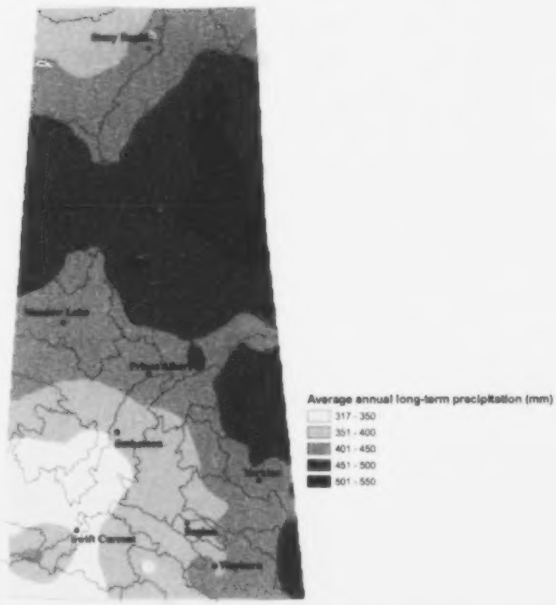
The quality of surface water is intimately connected with regional geology, water volume, biotic interactions and human activity. Most lakes in northern Saskatchewan which are underlain by Canadian Shield have low concentration of nutrients (oligotrophic lakes). Lakes in southern Saskatchewan typically occur on glacial deposits surrounded by nutrient-rich soils and therefore have greater nutrient concentrations (eutrophic lakes). Most northern lakes are freshwater (few dissolved salts), whereas many lakes in southern Saskatchewan are subsaline, with some being saline or hypersaline (having a greater salt concentration than that found in the oceans). Groundwater also has a profound influence on surface water quality. Water quality in streams, rivers and lakes that receive



Surface Water in Saskatchewan

Surface water in Saskatchewan can be classified according to flow (e.g. rivers, lakes), size (e.g. streams, rivers), permanency (e.g. perennial stream, ephemeral stream), productivity (e.g. nutrient poor, nutrient rich) and salinity (e.g. freshwater, saline). These water bodies formed as a result of historic geological processes and localized geologic properties. Within different regions of Saskatchewan the current geologic properties continue to have a major influence on water quality. This results in strong regional coherence that explains much of the diversity among water body types and water quality properties within Saskatchewan.

As previously noted, the portion of Saskatchewan's surface area covered by water is approximately 12%. However, surface waters are not distributed evenly throughout the province. Northern Saskatchewan has a greater proportion of water, including some of the largest lakes in Canada, while parts of southern Saskatchewan have very little surface water. A greater proportion of surface water is permanent in the north, whereas many smaller southern wetlands, potholes, streams and creeks do not have water in them year-round (i.e. they are intermittent or ephemeral). The amount of surface water, whether it be lake volume or stream flow, is a function of the balance between precipitation, evaporation, transpiration (evaporation from plants), interactions with soil moisture storage and groundwater, and inflow and outflow. The timing of precipitation also affects flow volume and lake levels. Northern Saskatchewan has greater precipitation (Figure 7) and little infiltration to groundwater. In southern Saskatchewan the volume of water during spring melt is a critical determinant of river flow, lake level and groundwater recharge. In southern Saskatchewan there is a strong connection between surficial groundwater and summertime river flow, lake level and wetland water level.



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groundwater will reflect some of the groundwater properties. Within the prairie region of Saskatchewan there is also geographical similarities in surface water properties. Studies suggest that glacial/non-glacial sediment types, groundwater composition and the balance of evaporation/precipitation are the principal determinants of this regional distribution (Last and Ginn 2005). The North and South Saskatchewan Rivers, which originate in the Rocky Mountains, have lower concentrations of nutrients and dissolved salts than many rivers arising within southern Saskatchewan. The large range in the concentration of nutrients, salts and dissolved organic carbon results in a great diversity of biological and chemical processes that occurs within Saskatchewan's surface waters.

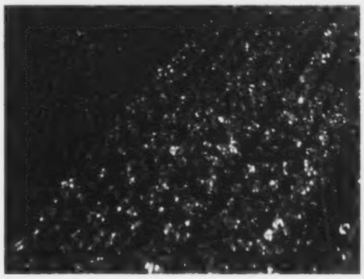
Surface water quantity analysis

The annual flow volumes and seasonal flow rates of Saskatchewan rivers are strongly connected with regional geology and climate. There are three broad types of river systems in Saskatchewan: those originating in the eastern slopes and foothills of the Rocky Mountains in Alberta, those originating in the Boreal Shield, and those originating on the southern plains and prairie regions.

The North and South Saskatchewan Rivers originate in the eastern slopes and foothills of the Rocky Mountains in Alberta. Up to 90% of the flow of these rivers is generated in the Alberta headwaters. The North and South Saskatchewan Rivers join east of Prince Albert to form the Saskatchewan River. These rivers have reliable annual flows and constitute the most secure surface water source for southern Saskatchewan. There are often two flow peaks on these rivers. The first, usually lower, peak in April or May is associated with snowmelt runoff from the prairie portion of the watershed, and the second peak in June comes from snowmelt at the higher mountain elevations combined with rainfall runoff in the foothills. Flows are sustained through late summer and in drier years by glacier melt at the highest mountain elevations. There are no major natural lakes on these systems which significantly modify flows in these rivers. However, reservoirs and water diversions have changed the seasonal average flow rates and reduced annual flow volumes, particularly on the South Saskatchewan River.

River systems in northern Saskatchewan include the Reindeer/Churchill and tributaries to Lake Athabasca and the Athabasca River. With reduced evaporation, transpiration, and infiltration rates, runoff in the Shield and Boreal Plain areas of Saskatchewan is much greater than in the southern plains. Most runoff is generated from spring snowmelt, but late spring and summer rains can also be significant. With the large number and size of lakes in northern Saskatchewan, and the later arrival of warmer temperatures, peak river flows and lake levels are often observed over the summer months rather than in the spring. There is little water use or development in northern Saskatchewan. The most significant project is the regulation of Reindeer Lake for hydropower and navigation.

Watersheds in southern Saskatchewan, exclusive of the main stems of the North Saskatchewan, South Saskatchewan and Saskatchewan Rivers, originate on glacial deposits; typically either depositional moraines or tills and glacial lake bottoms. The rivers themselves often follow glacial spillway channels and are underfit for the size of the valley they occupy. The water balance in southern Saskatchewan is dominated by soil moisture storage, wetland storage, evaporation, and transpiration. In many watersheds, the average annual runoff volume is less than 10% of the average annual precipitation. Almost all the annual runoff occurs as a result of snowmelt, with only extreme rainfall events generating any streamflow. In many prairie watersheds, only a small portion of the watershed area will contribute to streamflow in low to average runoff years. This is due to the storage capacity of prairie wetlands. In wetter years, some or all of the wetlands will fill and contribute to streamflow.



There are a number of watersheds in southern Saskatchewan which do not outlet into a major river system. These "closed watersheds" drain to an internal low area occupied by a "terminal lake." Examples of such watersheds are Old Wives Lake, the Quill Lakes, and Redberry Lake. With evaporation as the only way of discharging water from these basins, these lakes are often very high in salts. During extended droughts, some of these lakes may dry up completely.

Water use and development is extensive in all basins across southern Saskatchewan, particularly in the Milk River, Swift Current Creek, Old Wives Lake, and Qu'Appelle and Souris River basins.

Surface water quantity stressors

From an environmental perspective, water quantity stressors are related to departures from the natural flow regime due to human use and development. Stressors to water supply in Saskatchewan include climate change, natural variability, and increasing use and diversion both within Saskatchewan and in upstream jurisdictions. An additional stress to water supply is water quality degradation, which can render a water source unusable for the intended purpose.

Surface water quality analysis

Surface water quality is generally considered in the context of water use, where water use includes natural processes such as maintaining healthy fish populations and various human uses (e.g. drinking water, livestock watering, irrigation, industry, aesthetic-leisure activities). Specifically, water quality is a function of the properties and constituents within water in the context of these water uses. Constituents within water include nutrients, oxygen, bacteria, metals, and ions. The appropriate assessment of water quality involves understanding and evaluating natural processes, historic water quality, human impacts and water use.

Reconciling the large number of constituents and the range of their concentrations within the context of various water uses represents the fundamental challenge in summarizing water quality. The need for a tool to summarize the state of water quality led to the development of the Canadian Water Quality Index (WQI). This index has been adopted and adapted for use by many provinces, including Saskatchewan. The WQI assesses concentrations of several indicator constituents relative to objective concentrations. These constituents include nutrients, dissolved oxygen, dissolved ions, heavy metals, pesticides and bacteria. Annual WQI values are calculated based on the number of constituents that exceed their objective during the year, the total proportion of all exceedances, and the amount by which objectives are exceeded.

The objectives used in the WQI for assessing water quality are based on the Interim Surface Water Quality Objectives (Saskatchewan Environment 2006b) and those used by the Saskatchewan Watershed Authority in its assessment of source water quality. There are infrequent exceedances of these objectives observed in northern watersheds, resulting in high WQI ratings (good water quality). This may suggest good water quality in northern Saskatchewan; this may also suggest that a general template of water quality objectives is not applicable across the entire province (i.e. there is a need for watershed-based objectives). In southern Saskatchewan there is greater variability in the number and magnitude of objective exceedances, leading to a larger range in WQI values. Identifying areas with lower WQI values (poorer water quality) enables further

assessment to determine the causes – some of which may be natural (e.g. due to local geology), while others may result from human activity (e.g. Davies 2006) – and to determine the responses necessary to improve the water quality of the system.

Surface water quality assessment

The condition of water, as assessed using the WQI, varies geographically within Saskatchewan. Northern watersheds have relatively few constituents that exceed water quality objectives. For example, the Churchill River is classified as being healthy, with only aluminium exceeding its objective. At Emma lake, no exceedances were observed. In contrast, rivers in southern Saskatchewan often exceed the total phosphorus objective and, during winter, often do not meet the oxygen objective. Some rivers and lakes, including Battle River, Carrot River and Last Mountain Lake, exceed ionic objectives. In some southern rivers and lakes, concentrations of heavy metals are present in excess of their respective objectives. Not all exceedances are a result of human activity since baseline water quality is determined by regional geology, precipitation and biotic processes.

Surface water quality stressors

Factors resulting in deviations from the natural state threaten water quality and ecosystem function. This *State of the Watershed Report* analyzes a number of stressors that have the potential to reduce water quality in Saskatchewan. The actual impact depends on both the stressor and the intrinsic attributes of the waterbody. Surface waters in different geographical regions are susceptible to different stressors. Major stressors to surface water in northern Saskatchewan occur from both localized industry and regional long-range atmospheric transport. Lakes in the north have intrinsically lower acid neutralizing capacity than southern lakes, which makes them more susceptible to atmospheric acid deposition. Lakes and rivers in southern Saskatchewan may be susceptible to further increases in nutrient loading as a result of various human activities.

Geology and Hydrogeology of Saskatchewan

This section focuses on groundwater resources in southern Saskatchewan, which includes the agricultural zone and the fringe areas immediately north of it. In northern Saskatchewan, groundwater use is extremely limited and very little work has been done to investigate the resource. In southern Saskatchewan, where groundwater is an important component of the water supply, a significant amount of work has been done.

Geologic units may be broadly divided into bedrock and Quaternary or glacial "drift", which can be differentiated based on their characteristics and geologic history. Bedrock describes those rocks occurring below the base of the glacial deposits. Strictly speaking this includes Pre-Cambrian rocks, but these have no practical influence on the province's groundwater resources and will not be discussed further. For the purposes of this document, bedrock will refer to those sediments deposited prior to glaciation, which began approximately two million years ago. Therefore, the bedrock deposits relevant to the province's groundwater resources are sedimentary rocks which were deposited by, or adjacent to, shallow seas which intermittently covered Saskatchewan. Drift is those sediments between the top of the bedrock and the present ground surface. The drift is formed by unconsolidated deposits either directly via glaciers or by melt water associated with glaciation.

The bedrock and glacial deposits have been separated and classified into formations based on their history, characteristics and past depositional environment. Whenever a bedrock or glacial deposit is capable of yielding useable volumes of water to a water well, it is referred to as an aquifer. Both bedrock and glacial aquifers are commonly used as water sources. Glacial aquifers are broadly distributed throughout the province, while bedrock aquifers tend to be utilized primarily in the west central, southwest, south central and extreme southeast portions of the province.

Bedrock Aquifers

Bedrock formations were deposited prior to glaciation and are generally more extensive and consistent in thickness and characteristics than the glacial drift deposits. The deposits are marine and continental in origin. Deposition of bedrock sediments were contributed by slow regression of the sea interrupted by a rapid rise in sea level. Clay/shales were deposited in marine environments, fine sands near shore areas, and coal and interbedded sediments in the continental environments. The bedrock topography was formed by preglacial erosion and deposition, followed by glacial and fluvio-glacial erosion and deposition. The bedrock aquifers will be discussed in ascending order. For the most part bedrock aquifers occurring below the Ribstone Creek aquifer would be saline and are not considered here. It should be noted that there are a number of bedrock aquifers occurring below the Ribstone Creek aquifer.

Ribstone Creek Aquifer

The Ribstone Creek Formation is a sand member of the Lea Park Formation. Thin, fine-grained saturated sands and sandstones form the aquifer, which is limited to the western portion of Saskatchewan. In general, the aquifer is either too deep or yields water with a quality that is unsuitable for domestic or municipal uses. The depth of the aquifer is approximately greater than 500 meters in the Cypress Hills area and less than 25 meters in the Lloydminster area. Due to its generally poor quality, the water is primarily used by the oil industry.

Judith River Formation

The Judith River Formation consists predominately of continental clay, silts and fine sands. The Judith River does not form a single, discrete aquifer; rather, it forms an aquifer system consisting of a number of inter-related aquifers. The Judith River is a wedge-shaped deposit and occurs in the southwestern part of Saskatchewan. Figure 8 illustrates its spatial extent and distribution. It is a major regional aquifer and is thickest in the western portion of the province, thinning toward the east. Some of the thinning of the formation may be the result of erosion during the deposition of the Tyner Valley and Hatfield Valley Aquifers, which are incised into both the Bearpaw and Judith River Formations. In general, water from the aquifer is soft but is variable depending on the geologic structure and local recharge. Although the water is generally soft, it is still considered to be of relatively poor quality due to its high mineral content. Aquifer yields range from 10 to 60 imperial gallons per minute (igpm), but generally will be less than 20 igpm. Where the aquifer thickness is limited, yield will be correspondingly less.

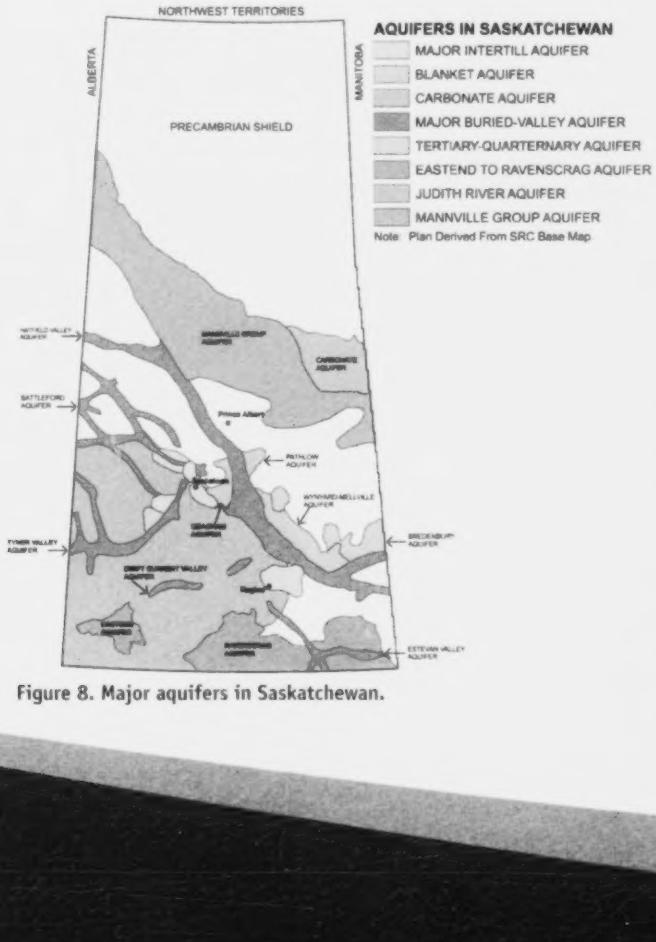


Figure 8. Major aquifers in Saskatchewan.

Bearpaw Sands and Silts

The Bearpaw Formation overlies the Judith River Formation and consists primarily of marine shales. The marine shales do not have potential as an aquifer, but in some areas sand deposits within the shale occur. These sand members may form locally significant aquifers capable of providing a water supply for domestic and small municipal users. In Saskatchewan, these members have been named in ascending order: Outlook, Matador, Demaine, Ardkenneth and Cruikshank members. The aquifers formed by the sand members are limited in extent due to a lack of lateral continuity. Of the various sand members, only the Demaine and Ardkenneth are important sources of water. Water from these sand members is soft, but generally of poor quality because it is highly mineralized.

Eastend, Whitemud, Frenchman, Battle, and Ravenscrag Formations

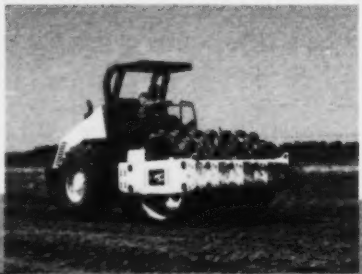
The Late Cretaceous Eastend, Whitemud, Frenchman, Battle, and Tertiary Ravenscrag Formations occupy the southern portion of Saskatchewan. The Eastend Formation represents the transition from marine to non-marine sedimentation. From the view of groundwater resources, the separation of each formation could not be separated from geophysical logs and has been grouped as one unit. It is often referred to as the Eastend to Ravenscrag Formation forming the Eastend to Ravenscrag Aquifer. The spatial extent of the Eastend to Ravenscrag Aquifer is limited to the southern-most portions of the province and in the Cypress Hills uplands. Figure 8 illustrates its spatial extent and distribution. The sand facies of the Eastend to Ravenscrag Aquifer serves as an important regional aquifer for domestic and municipal users. As in the case of the Judith River, this unit consisted of a number of discrete aquifers and must be considered as an aquifer system. The aquifer system has been further divided into five discrete units. From west to east, these units are: the Shaunavon Aquifer System, the Coronach Aquifer System, the Ormiston and Bengough Aquifer Systems, and the Bienfait Aquifer Systems.

Quaternary Aquifers

Approximately two million years ago, Saskatchewan was subjected to a number of episodes of glacial advance and retreat. Glacial movement across the landscape resulted in erosion and deposition of sediments on top of the bedrock surface. Sediments deposited during glacial episodes included sorted and unsorted material. The unsorted materials are referred to as glacial tills, which are mixtures of silt, clay and sand. The sorted sediments were deposited from glacial meltwater at the ice front. These deposits consist of sand, silt and clay and gravel, with saturated sand and gravels forming glacial aquifers. Repeated episodes of glacial advance and retreat resulted in extremely complex geologic conditions. Glacial aquifers tend to be subject to rapid lateral and vertical changes in extent, thickness, and distribution. It is safe to say that they tend to be much more variable than the bedrock aquifers. The glacial drift has been divided into several till and intertill units representing the glacial and interglacial periods which occurred. The glacial drift aquifers in Saskatchewan, in ascending order, are: the Empress Group Aquifers, the Sutherland Group and Saskatoon Group Aquifers, and the Surficial Drift Aquifers.

Empress Group

Deposits occurring between the bedrock surface and the glacial drift are referred to as the Empress Group. Where sand and gravel components of these deposits are saturated they form Empress Group Aquifers, which may be broad, laterally extensive aquifers. However, the Empress Group most commonly forms what are known as buried valley aquifers. These buried valley aquifers were formed by deposition of sediments and glacial sand and gravel at the base of ancient river valleys which had been eroded into the pre-glacial land surface. The Empress Group consists of pre- and post-glacial stratified sand, gravel, silt and clay. These sediments are highly permeable and extend hundreds of kilometers. In general, these aquifers are long and narrow, similar to a modern valley, but due to repeated glacial activity they have been deeply buried and there is no surface expression of these ancient river valleys.



In Saskatchewan, the major aquifers formed by the Empress Group are: the Hatfield Valley Aquifer, the Tyner Valley Aquifer, the Battleford Valley Aquifer, the Swift Current Valley Aquifer, and the Estevan Valley Aquifer. The Hatfield Valley Aquifer is the largest buried valley aquifer in Saskatchewan.

Water quality from these aquifers is variable, but is generally fairly poor to quite poor for anything other than industrial purposes. Yields are also variable, but may be suitable for large industrial and municipal uses.

Sutherland and Saskatoon Groups

The Sutherland and Saskatoon Groups occur above the Empress Group. Both groups consist mainly of till, but may contain interbedded sand and gravel within the till. The saturated sand and gravel form potential aquifers. The thickness, depth, and extent of these aquifers are extremely variable. They may occur at depths of up to 200 metres or more, and as shallow as a few metres. Water quality and yield from these aquifers are also extremely variable. These aquifers are used for everything from domestic to large municipal and industrial uses.

Surficial Drift Aquifers

The surficial drift aquifers are the uppermost groundwater zone. These aquifers are formed by saturated sands and silts deposited by eolian (wind blown) processes and streams and rivers. Given their proximity to the surface, they are most likely to be directly influenced by climatic conditions. These deposits may be well-sorted and highly permeable. Water quality from the surficial drift aquifers are less mineralized than the deeper aquifers and may provide a water supply to domestic users and smaller municipal and industrial users. Wells completed in surficial aquifers are generally large-diameter bored wells. Recharge mainly originates from precipitation and during spring runoff infiltrating into the water table. In general, these aquifers are typically more vulnerable to drought and contamination than the deeper aquifers.

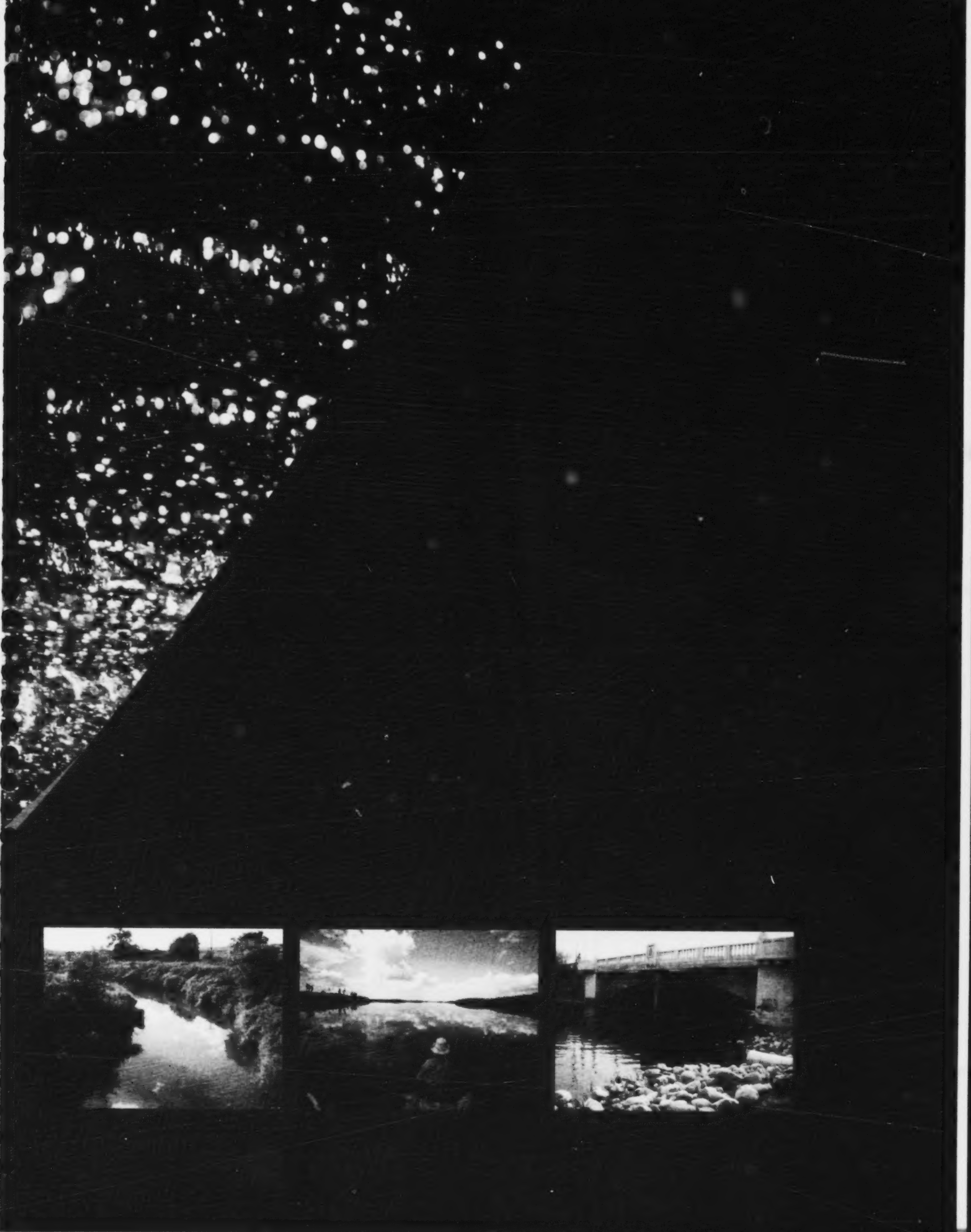
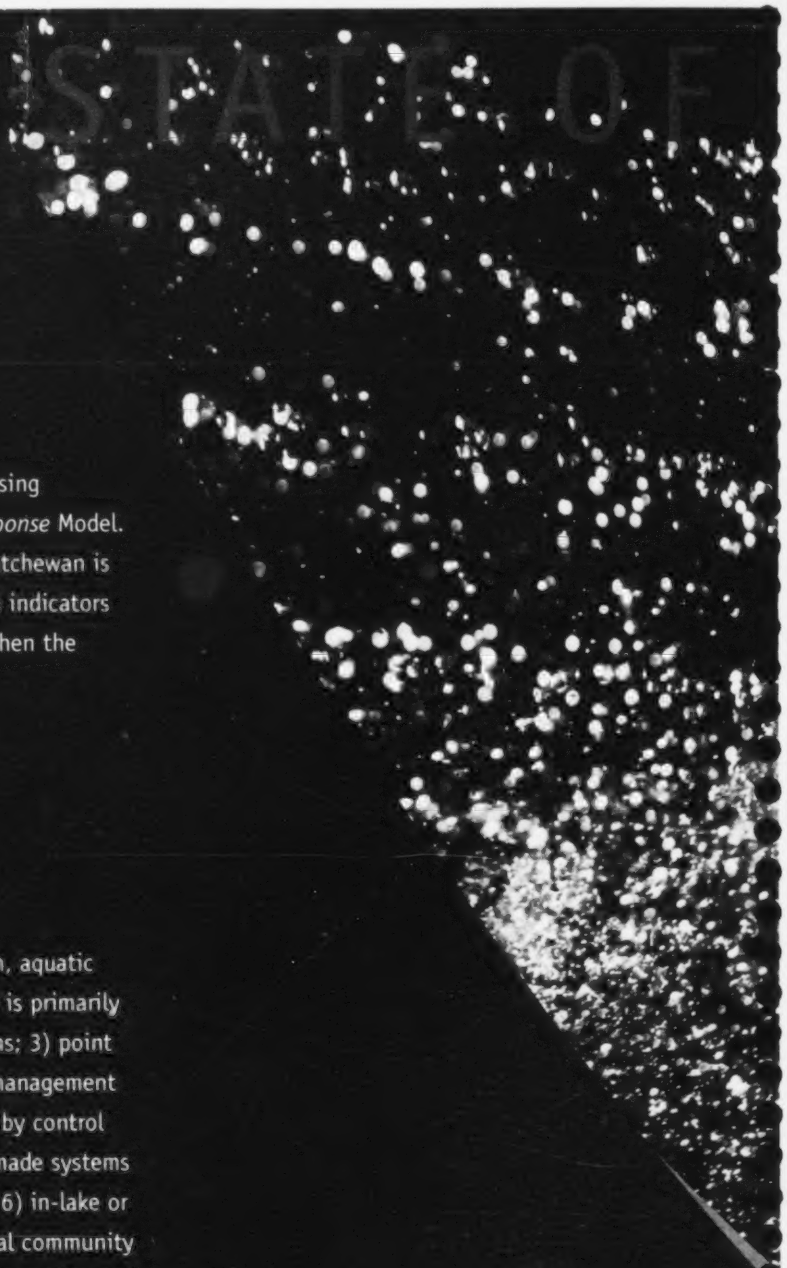


Table 2. Select criteria to assign watershed health grades to Stressor, Condition, and Response indicators.

Condition Indicators		Impaired	Stressed	Healthy
Water Quality	The Water Quality Indicator is an assessment of the chemical, biological and physical constituents within the water.	< 45	45 to 79	80 to 100
Surface Water Quantity	Surface water quantity estimates the percentage of annual flow that remains as net available surface water.	< 20%	20% to 40%	> 40%
Riparian Health	Riparian health measures the ability of a riparian area to perform the essential functions of trapping sediment, filtering runoff, stabilizing streambanks, recharging groundwater, and providing wildlife habitat.	< 60	60 to 79	80 to 100
Riparian Buffer	Riparian buffer is the percent of permanent cover within a 40 metre strip of the adjacent waterway.	< 26	26 to 74	75 to 100
Permanent Cover	Permanent cover is the percentage of perennial vegetation within southern Saskatchewan watersheds.	< 27%	27% to 46%	> 46%
Rangeland Health	Rangeland health measures the ability of a rangeland to perform the essential functions of reducing soil erosion, increasing water infiltration and reducing runoff.	< 50	50 to 74	> 74
Environmental Acid Deposition	Environmental acid deposition measures the exceedance of critical load of atmospheric sulphur and nitrogen deposition.	>30%	20% to 30%	< 20%
Stressor Indicators	**Indicator Descriptions**	**High stress**	**Moderate stress**	**Low stress**
Human Population Size	Human population size is the number and distribution of people that reside in Saskatchewan.	> 111,700 people	31,900 to 111,700 people	< 31,900 people
Numerical Change in Human Population	Numerical change in human population is the change in the number and distribution of people that resided in the watershed between 1991 and 2001.	> 3,900 people	400 to 3,900 people	< 400 people
Human Population Density	Population density is a measurement of the number of people per square kilometre.	> 6.50 people/km²	2.60 to 6.50 people/km²	< 2.60 people/km²
Roads	This indicator reports on the percentage of the watershed ecologically impacted by roads.	> 23%	9% to 23%	< 9%
Surface Water Allocation	Surface water allocation assesses the percentage of the supply of surface water that is allocated from each watershed.	> 40%	20% to 40%	< 20%
Groundwater Allocation	Groundwater allocation estimates the amount of groundwater that is allocated from each watershed.	>11,200 dam³	3,700 to 11,200 dam³	< 3,700 dam³
Aquatic Fragmentation	Aquatic fragmentation estimates the potential hydrologic alteration caused by control structures.	> 0.70 barriers/km	0.20 to 0.70 barriers/km	< 0.20 barriers/km

Stressor Indicators	Indicator Descriptions	High stress	Moderate stress	Low stress
Spring Runoff Potential of Impervious Areas	Potential spring runoff from urban impervious areas estimates the maximum percentage of spring flow that is associated with spring runoff from impervious areas.	> 20%	2% to 20%	< 2%
Municipal Wastewater Effluent Discharge	This indicator measures the assimilative capacity of wastewater effluent discharges within the watersheds.	>0.78 people/dam³/ year	0.17 and 0.78 people /dam³/year	<0.17 people/dam³/ year
Livestock Density	This indicator measures the density of livestock per square kilometre.	> 11 AUEs/km²	2 to 11 AUEs/km²	< 2 AUEs/km²
Livestock Operations	This indicator assesses the potential risk that livestock operations pose to source water.	> 249	129 to 249	< 129
Soil Erosion (tonnes/hectare/year)	Soil erosion is an estimate of the potential of soil erosion on cropped land caused by precipitation and surface runoff.	> 22 tonnes/hectare/ yr	11 to 22 tonnes/ hectare/yr	< 11 tonnes/hectare/ yr
Fertilizer Inputs	Fertilizer inputs measures the intensity of fertilizer use by watershed between 1986 and 2001.	> $20.95/hectare	$5.90 to $20.95 /hectare	< $5.90/hectare
Pesticide Inputs	Pesticide inputs measures the intensity of pesticide use by watershed between 1986 and 2001.	> $22.75/hectare	$8.96 to $22.75 /hectare	< $8.96/ hectare
Manure Application	Manure application measures the percentage of the watershed, in 2001, where manure was applied.	> 0.75%	0.28% and 0.75%	< 0.28%
Density of Oil and Gas Spills	Density of oil and gas spills is a measurement of the number of oil and gas spills per 1,000 square kilometres over a ten-year period	> 38.39 spills/1,000 km²	6.39 to 38.39 spills/1,000 km²	< 6.39 spills/1,000 km²
Annual Volume of Oil and Emulsion Spills	Volume of oil and emulsion spills is a measure of the average annual volume of oil and emulsion spills per square kilometre.	> 50 litres/km²	10 to 50 litres/km²	< 10 litres/km²
Annual Volume of Saltwater Spills	Volume of saltwater spills is a measure of the average annual volume of saltwater spills per square kilometre.	> 100 litres/km²	10 to 100 litres/km²	< 10 litres/km²
Mine Density	This indicator compares the density of active, inactive and abandoned mines between watersheds.	> 6.80 mines/1,000 km²	1.18 to 6.80 mines/1,000 km²	< 1.18 mines/1,000 km²
Environmental Stress of Mines	This indicator measures the stress that active, inactive and abandoned mines are placing on the environment.	> 58	19 to 58	< 19
Percent of Forested Area Disturbed in Last 20 Years	This indicator measures the percent of forested area that has been disturbed by human activities within watersheds within the past 20 years.	> 2.52%	1.19% to 2.52%	< 1.19%
Density of Landfills	This indicator measures the density of landfills per 1,000 square kilometres.	> 2.63 landfills/1,000 km²	1.40 to 2.63 landfills/1,000 km²	< 1.40 landfills/1,000 km²
Environmental Risk of Contaminated Sites	This indicator measures the stress that contaminated sites are placing on the environment.	> 1.05	0.38 to 1.05	< 0.38

Stressor Indicators	Indicator Descriptions	High stress	Moderate stress	Low stress
Density of Industrial Waste Sites	Industrial waste site density is a measure of the number of industrial waste sites per 1,000 square kilometres.	> 3.63/1,000 km²	1.03 to 3.63 /1,000 km²	< 1.03/1,000 km²
Industrial Waste Disposed and Released	Industrial waste disposed and released is a measure of the tonnes of pollutants disposed of and released per square kilometre from industrial waste sites in Saskatchewan.	>5.19 tonnes/km²	1.48 to 5.19 tonnes/km²	< 1.48 tonnes/km²
Wetland Loss	This indicator estimates the area of wetland loss by watershed between 1985 and 1999.	> 8%	3% and 8%	< 3%
Response Indicators		**Absent/Gap**		**Present**
Water Conservation	This indicator reports on the water conservation methods employed within Saskatchewan.	Yes		Yes
Watershed Education	This indicator reports on the number and type of watershed-related educational programs delivered at schools.	Yes		Yes
Conservation Stewards	This indicator reports on the number of volunteer stewards within a watershed.	Yes		Yes
Stewardship Workshops	This indicator reports on the number of stewardship workshops per watershed.	Yes		Yes
Agricultural Beneficial Management Practices	This indicator outlines the agricultural Beneficial Management Practices that are being promoted in the province.	Yes		Yes
Watershed and Land Use Planning	This indicator assesses the land use planning activities by watershed.	Yes		Yes
Water Quality Monitoring and Management	This indicator reports on the government-led water quality monitoring programs that are active by watershed.	Yes		Yes
Water Quantity Monitoring and Management	This indicator reports on the government-led water quantity monitoring programs that are active by watershed.	Yes		Yes
Protected Areas	This indicator reports on the percent of protected area by watershed.	Yes		Yes
Legislative Tools, Strategies, Policies, and Guidelines	This indicator repots on the federal and provincial legislation, strategies, policies and guidelines that have been developed to address environmental issues in Saskatchewan.	Yes		Yes



This section summarizes the indicators for assessing watershed health using the *Stress-Condition-Response* Model. The health, or condition, of watersheds in Saskatchewan is the focus of this report; therefore, the condition indicators are reported first, followed by the stressor and then the response indicators.

7.1 Condition Indicators

Water Quality Indicator

The issue

Good quality water is essential for human health, aquatic ecosystems and economic growth. Water quality is primarily affected by: 1) geology; 2) precipitation patterns; 3) point and non-point pollution; 4) land use and land management practices; 5) modifications to flow rates caused by control structures, such as dams, weirs and other man-made systems that modify how water moves downstream; and 6) in-lake or in-stream biological processes (i.e. the biological community within the water has feedback that affects water quality, and changes in a community structure can have large impacts on water quality) (Environment Protection Authority, New South Wales 2003).

Water Quality Indicator in Saskatchewan

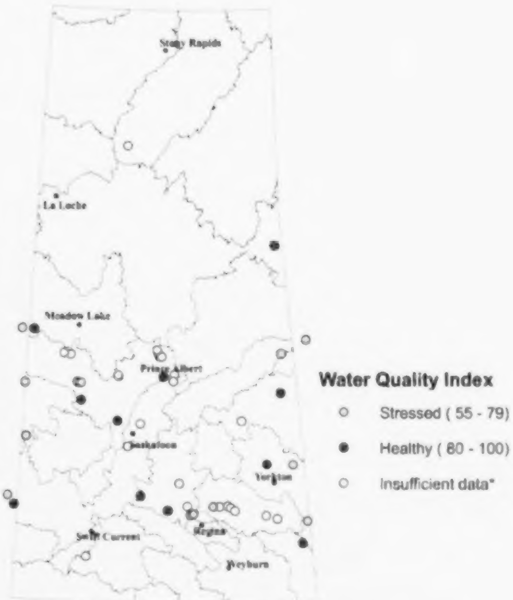


Figure 9. Five-year average of Water Quality Index values calculated by sample location: 2000 to 2004.

*Fewer than three of the five years have calculated Water Quality Index values.

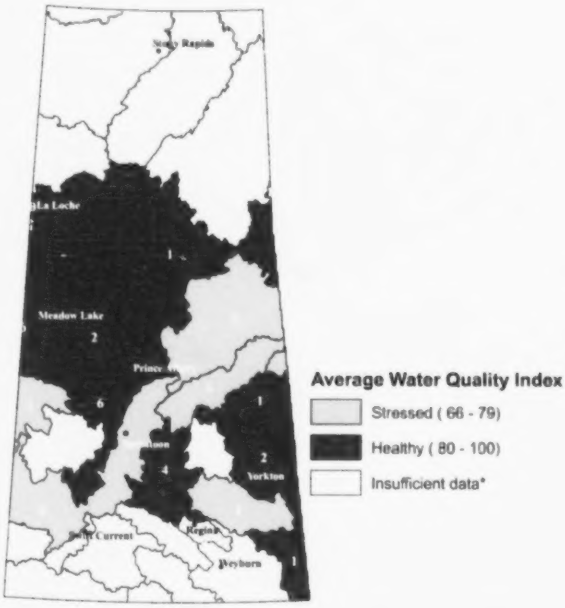


Figure 10. Five-year average of Water Quality Index values calculated by sample location: 2000 to 2004.

Sufficient data were available to calculate the Water Quality Index for 48 water quality sampling sites in twelve of Saskatchewan's watersheds between 2000 and 2004. The average Water Quality Index was healthy for seven watersheds and stressed for five watersheds.

Figure 11. Ten-year average of Water Quality Index values calculated by sample location: 1990 to 1999.

Figure 12. Ten-year average of Water Quality Index values calculated by sample location: 1990 to 1999.

Note: the numbers shown within the watersheds are number of sample sites.

Sufficient data existed to calculate the Water Quality Index for 31 water quality sites in 10 of Saskatchewan's watersheds between 1990 and 1999. The average Water Quality Index (WQI) was assessed for seven watersheds and healthy for three watersheds.

Indicator

This indicator reports on the water quality of Saskatchewan's surface watersheds. The Water Quality Index is used to assess the chemical, biological, and physical constituents of the watershed and provides a means of summarizing the overall water quality.

The Water Quality Index (WQI) is an effective means for summarizing a large number of water quality parameters. The WQI was adopted in 1999 by the Canadian Council of Ministers of the Environment. It is based on a formula developed by the British Columbia Ministry of Environment, Lands and Parks and modified by Alberta Environment (Canadian Council of Ministers of the Environment 2001).

In the application of the WQI, values for selected water quality parameters (e.g., dissolved oxygen, nutrients, heavy metals) are compared to the Surface Water Quality Objectives for Saskatchewan (Saskatchewan Environment 2000). The results of the comparisons are combined to provide a water quality rating (e.g., Good, Fair, Poor) for individual water bodies. The advantages of this index are that it summarizes multiple water quality parameters in a simple manner and it is effective as a communication tool. When the same objectives and conditions are used, the index can be used to assess relative differences in water quality between sites and over time; however, be careful when comparing among sites because of natural variability in water quality conditions (e.g., a naturally saline lake would naturally have high concentrations of dissolved salts compared to a freshwater lake). The disadvantages of using the index include a loss of information, the sensitivity of the results to the formulation of the index, the selection of objectives as a basis for assessing water quality, and the loss of information on interactions between variables.

The water quality parameters and guidelines/objectives used for calculating the Water Quality Index are outlined in Table ...

Sufficient data were available to calculate the Water Quality Index for 30 water quality sites in twelve of Saskatchewan's watersheds between 1990 and 1999. The average Water Quality Index (WQI) was stressed for seven watersheds and healthy for five watersheds.

Indicator

This indicator reports on the water quality of an individual waterbody within a watershed. The Water Quality Index is used to assess the chemical, biological, and physical constituents within waterbodies and provides a means of summarizing the overall water quality.

The Water Quality Index (WQI) is an effective means for summarizing a large number of water quality parameters. The WQI was created in 1997 by the Canadian Council of Ministers of the Environment. It is based on a formula developed by the British Columbia Ministry of Environment, Lands and Parks and modified by Alberta Environment (Canadian Council of Ministers of the Environment 2001).

In our application of the WQI, values for various water quality parameters (e.g. dissolved oxygen, nutrients, fecal coliform) are compared to the Interim Surface Water Quality Objectives for Saskatchewan (Saskatchewan Environment 2006b). The results of the comparisons are combined to provide a water quality ranking (e.g. Good, Fair, Poor) for individual water bodies. The advantages of this index are that it summarizes multiple water quality parameters in a single number, and it is effective as a communication tool. When the same objectives and variables are used, the index can be used to convey relative differences in water quality between sites and over time [care must be taken when comparing among sites because of natural variability in water quality constituents (e.g. a naturally saline lake would naturally have high concentrations of dissolved ions compared to a freshwater lake)]. The disadvantages of using the index include a loss of information, the sensitivity of the results to the formulation of the index, the reliance on objectives as a basis for assessing water quality, and the loss of information on interactions between variables.

The water quality parameters and associated objectives used for calculating the Water Quality Index are outlined in Table 3.

Figure 11. Ten-year average of Water Quality Index values calculated by sample location: 1990 to 1999.

*Fewer than five of the ten years have calculated Water Quality Index values.

Figure 12. Ten-year average of Water Quality Index values calculated by sample location: 1990 to 1999.

Note: the numbers shown within the watersheds are number of sample sites.

Table 3. Water quality parameters used for calculating the Water Quality Index.

Water Quality Parameter	Non-compliance if:	Value 1	Value 2	Unit
Arsenic Total	>	5		µg/L
Chloride Dissolved	>	100		mg/L
Chromium Total	>	1		µg/L
Mercury	>	0.026		µg/L
Unionized Ammonia (as Nitrogen)*	>	19		µg/L
Oxygen Dissolved (Field)	<	5.5		mg/L
pH	<>	6.5	9.0	Unit
Sodium Dissolved	>	100		mg/L
2`4-D	>	4		µg/L
MCPA	>	0.025		µg/L
Aluminum Total	>	0.1		mg/L
Sulphate	>	500		mg/L
Coliforms Fecal	>	1000		units/100mL
Phosphorous Total	>	0.1		mg/L
Nitrogen Dissolved NO_3 & NO_2	>	1		mg/L
Chlorophyll *a* (For lakes only)	>	50		µg/L

* Unionized ammonia is calculated from total ammonia nitrogen, pH, and temperature.

The index is calculated using three components that relate to water quality objectives:

Scope - How many? - The number of water quality variables that do not meet objectives in at least one sample during the index period, relative to the total number of variables measured.

Frequency - How often? – The number of individual measurements that do not meet objectives, relative to the total number of measurements made in all samples for the index period of interest.

Amplitude - How much? - The amount by which measurements which do not meet their objectives depart from those objectives.

Rating Scheme

The Water Quality Index values range between 0 and 100, with zero representing the worst water quality and 100 representing the best water quality. Once the WQI value has been calculated, the value can be further simplified by assigning it to one of several descriptive categories (Canadian Council of Ministers of the Environment 2001):

Excellent: (WQI value 95-100) – water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels. These index values can only be obtained if all measurements are within objectives virtually all of the time.

Good: (WQI value 80-94) – water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.

Fair: (WQI value 60-79) – water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.

Marginal: (WQI value 45-59) – water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.

Poor: (WQI value 0-44) – water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

For this document condition indicators are grouped into three categories: healthy, stressed, and impaired. Therefore, for this indicator the WQI categories have been grouped together into the following three categories:

Water Quality Index

Healthy: The Water Quality Index value is between 80 and 100.

Stressed: The Water Quality Index value is between 45 and 79.

Impaired: The Water Quality Index value is less than 45.

Data Source: Water Quality Index values are from: Saskatchewan Environment's Surface Water Monitoring Program; the Prairie Provinces Water Board's Monitoring Program; the Saskatchewan Watershed Authority's River and Lake Water Quality Monitoring; the Saskatchewan Watershed Authority's Lake Stewardship Monitoring Program; and Environment Canada's Environmental Effects Monitoring Program.

Data Handling: Water Quality Index values are based upon multiple sampling dates per year. To ensure consistency of reporting, only sites with at least three water quality samples per year are included in this indicator. Yearly Water Quality Index values from 1990 to 1999 were averaged to obtain the ten-year values, and Water Quality Index values from 2000 to 2004 were averaged to obtain the five-year values.

Data Quality/Caveat: There are limitations in the representation of this indicator by watershed. The watersheds are shaded based on the average Water Quality Index value for all of the water quality sampling locations within that watershed. However, the Water Quality Index for any one watershed may be based on one water quality sampling location.

Response to the issue

A range of legislative tools, strategies and policies assist in protecting and improving water quality in Saskatchewan, including:

- *The Environmental Management and Protection Act, 2002*, administered by Saskatchewan Environment;
- the *Fisheries Act*, regulated by Fisheries and Oceans Canada;
- the Interim Surface Water Quality Objectives (Saskatchewan Environment 2006b); and
- Saskatchewan's Safe Drinking Water Strategy (see **Legislative Tools, Strategies, Policies and Guidelines**).

In addition to legislative tools, there are a number of federal and provincial government initiated monitoring programs in the province that monitor the quality of surface and/or groundwater for a variety of purposes (see **Water Quality Monitoring and Management Programs**). These monitoring programs include:

- Saskatchewan Environment's Surface Water Monitoring Program;
- The Prairie Provinces Water Board's Monitoring Program;
- The Saskatchewan Watershed Authority's River and Lake Water Quality Monitoring;
- The Saskatchewan Watershed Authority's Lake Stewardship Monitoring Program;
- The Saskatchewan Watershed Authority's Rural Water Quality Advisory Program;
- Saskatchewan Environment's Intensive Livestock Operations' Monitoring Program;
- Saskatchewan Environment's Cumulative Effects Monitoring Program; and
- Environment Canada's Environmental Effects Monitoring Program.

Surface Water Quantity Indicator

The issue

Surface water quantity is the amount of surface water within a watershed. More than 12% of Saskatchewan is covered by surface water found in lakes, rivers and wetlands (Government of Saskatchewan 2002a). In Saskatchewan, surface water is used for many purposes, including human consumption, ecosystem health, and economic activities such as industrial uses, power generation, and agriculture.

The natural fluctuations in stream flows are integral for sustaining the biodiversity and the health of connected ecosystems, such as wetlands and riparian areas. Changes in flow regimes affect the aquatic ecology of these ecosystems and may result in alterations in aquatic habitat, aquatic communities, riparian zones, floodplains and wetlands, the stability of river channels, and water levels.

The amount of flow in a river is affected by several factors, including:

- precipitation;
- soil infiltration rate;
- groundwater discharge;
- evapotranspiration;
- aquatic fragmentation and water regulation;
- water withdrawals; and
- water inputs from anthropogenic sources such as irrigation, wastewater, and stormwater runoff from impervious areas.

Surface Water Quantity Indicator in Saskatchewan

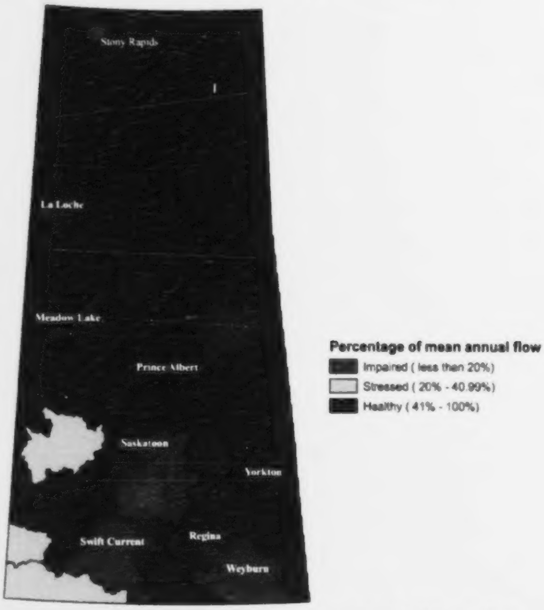


Figure 13. Percentage of annual flow as net available surface water.

Three watersheds in Saskatchewan are impaired and have less than 20% of the annual flow as net available surface water. The three watersheds that are impaired include the Upper Qu'Appelle River, the Upper Souris River and the Old Wives Lake Watersheds. The Cypress Hills North Slope, Eagle Creek and Milk River Watersheds are classified as stressed.

Indicator							
Net Available Surface Water	=	Mean annual flow	×	Downstream allocations (basin multiplier)	-	Internal allocations
Percentage of Annual Flow as Net Available Surface Water	=	$\frac{\text{Net available surface water}}{\text{Mean annual flow}}$				

The net available surface water can be roughly estimated by subtracting the sum of water allocations within a watershed from the downstream obligations (whether apportionment or in-stream) from the estimated natural runoff volume. In the case of major rivers that cross inter-provincial or international boundaries, the available supply would be based on the current supply received minus the existing allocations and downstream obligations (see Appendix 2 for basin multipliers).

Rating Scheme

Surface Water Quantity
Healthy: Greater than 40% of the annual flow as net available surface water.
Stressed: Between 20% and 40% of the annual flow as net available surface water.
Impaired: Less than 20% of the annual flow as net available surface water.

Data Source: The estimated median flow volumes were obtained from 1) the Saskatchewan Watershed Authority's Hydrology Services; and 2) the Saskatchewan Watershed Authority's discussion document *Conserving our Water: A water conservation plan for Saskatchewan (2004)*. Median runoff volumes for Old Wives Lake and Cypress Hills North Slope Watersheds were obtained from the Saskatchewan Rural Water Mapping Initiative, as hydrometric flow studies have not been done on these two watersheds. The Saskatchewan Rural Water Mapping Initiative is a tool for surface water resource planning developed by a multi-agency team, lead by Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration (AAFC-PFRA). Internal surface water allocations were obtained from the Saskatchewan Watershed Authority's Surface Water Database.

Data Quality/Caveats: Available data do not allow for the calculation of actual water use. Allocation and use are not synonymous: allocation refers to the volume of water that a project is allowed to withdraw; use refers to the volume that is actually withdrawn.

Response to the issue

The primary response to pressures of surface water extraction is through the approval and licensing of water use projects. The Saskatchewan Watershed Authority is responsible for the management of surface water in the province through the approval and licensing of water use projects.

Any surface or groundwater use, with the exception of domestic use, requires approval pursuant to *The Saskatchewan Watershed Authority Act, 2005* and *The Ground Water Regulations* (see **Legislative Tools, Strategies, Policies, and Guidelines**).

In addition to legislation, monitoring programs have also been established in the province to assess surface water quantity (see **Water Quantity Monitoring and Management**). Some of the government-initiated programs include:

- the Water Survey of Canada, an Environment Canada initiative;
- the Prairie Provinces' Water Board; and
- the Saskatchewan Watershed Authority's Provincial Streamflow Forecast.

Groundwater Quantity Indicator

The issue

Groundwater is a primary source of drinking water for the majority of rural consumers because of its availability over large geographic areas and because of generally lower treatment costs. An adequate supply of groundwater is necessary to supply drinking water demands and is also an important resource for industry, irrigation, and agriculture. The Saskatchewan Watershed Authority is responsible for managing and protecting groundwater as source water and for regulating its use through allocation.

Groundwater Quantity Indicator in Saskatchewan

Quantifying groundwater is challenging. The actual quantity of water available for use is difficult to estimate, and money available for groundwater research is limited. Therefore, a secondary or surrogate factor such as total groundwater use or observation well data is used to

estimate the state of our groundwater sources. Groundwater use data provide an indication of the stress put on the resource, while observation data indicate the state of the net available water (total available water less any uses) in the few aquifers for which data are available.

Response to the issue

The primary response to the pressures of groundwater extraction is through the approval and licensing of water use projects. The Saskatchewan Watershed Authority is responsible for the management of groundwater in the province through the approval and licensing of water use projects.

Construction, alteration, extension or operation of works, and the right to use water requires the Saskatchewan Watershed Authority's approval. The Authority issues approvals for the construction and operation of water works and issues water rights for the sustainable use of groundwater and surface water for domestic, municipal (source water only), agricultural, industrial, recreational and wildlife purposes.

A person owning or occupying land that adjoins a lake, stream, storage pond, dugout or groundwater source is not required to obtain an approval for domestic purposes. Domestic water use is defined as water that is to be used for household and sanitary purposes, farm chemical spraying, watering lawns and gardens, and water used for non-intensive livestock and poultry operations.

Any surface or groundwater use, with the exception of domestic use, requires approval pursuant to *The Saskatchewan Watershed Authority Act, 2005* and *The Ground Water Regulations* (see **Legislative Tools, Strategies, Policies, and Guidelines**).

Whether or not an aquifer can support a particular use is determined from test drilling, analysis of associated geologic and hydrogeologic information, and by pump testing the well. A groundwater investigation is required by the proponent to ensure that the groundwater source can sustain the proposed development without any adverse impacts on the source or on existing groundwater users. The regulatory process ensures the sustainability and environmentally-sound management of groundwater resources in Saskatchewan.

In addition to legislation, the Saskatchewan Watershed Authority and Saskatchewan Research Council (SRC) have established an observation well network (see **Water Quantity Monitoring and Management**) to monitor changes in specific aquifers around Saskatchewan. The network was established in 1964 with the initial intention of measuring natural fluctuations in groundwater levels. Sites were selected based on their geohydrological variety and in aquifers where SRC was involved in more detailed geohydrological activities.

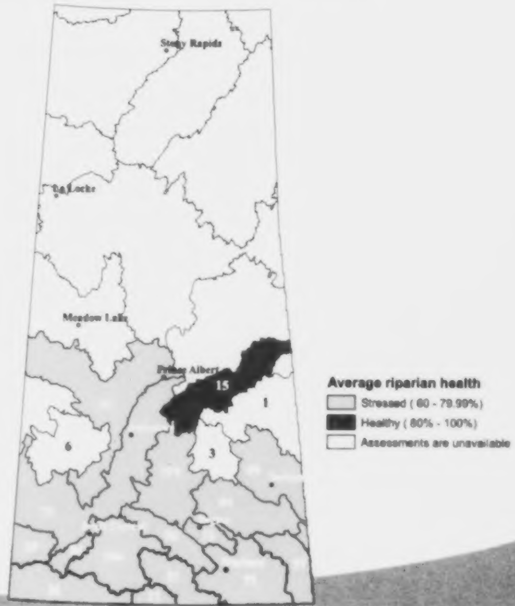
Riparian Health Indicator

The issue

Riparian areas perform many functions, including: improving water quality through the filtration of nutrients and contaminants from runoff; reducing erosion by dissipating stream and wave energy associated with high water levels; trapping sediment and capturing streambed load; stabilizing streambanks and shorelines; groundwater recharge; and enhancing aquatic and terrestrial habitat (Hansen et al. 2000).

A riparian zone is the interface between terrestrial and aquatic ecosystems, including the terrestrial areas adjacent to waterbodies that are influenced by elevated water tables or flooding (and by the ability of the soils to hold water).

Riparian Health Indicator in Saskatchewan



Note: the numbers shown within the watersheds are the number of assessments used to calculate the average lotic riparian health assessment scores. The riparian health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Figure 14. Average lotic riparian assessment scores by watershed.

Currently, riparian assessments on lotic systems (flowing waterways, e.g., rivers or streams) are available for 16 of the 29 watersheds in Saskatchewan. The Carrot River Watershed has an average lotic health score of healthy; the other 15 watersheds have an average lotic health score of stressed.

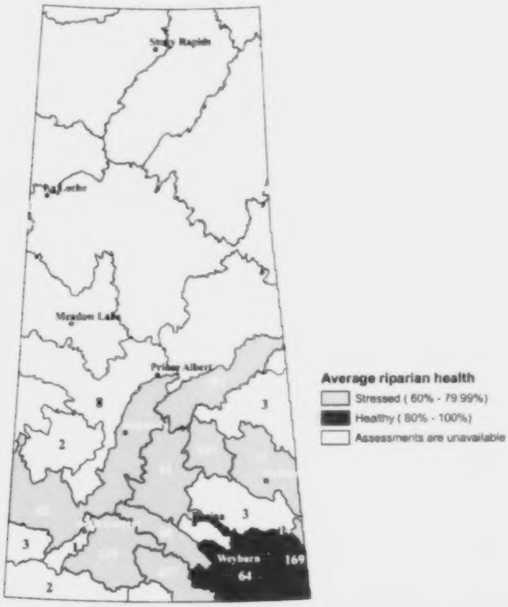


Figure 15. Average lentic riparian assessment scores by watershed.

Note: the numbers shown within the watersheds are the number of assessments used to calculate the average lentic riparian health assessment scores. The riparian health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Currently, riparian assessments on lentic systems (still water, e.g., lakes or ponds) are available for 17 of the 29 watersheds in Saskatchewan. The Upper and Lower Souris River Watersheds have an average lentic health score of healthy, and the other eight watersheds have an average lentic health score of stressed.

Indicator

The lotic (flowing water) and lentic (still water) riparian health assessments developed by Hansen et al. (2000) use vegetation, soil and hydrology factors to assess the functional ability and management and ecological considerations of the riparian area. The biotic and abiotic information are weighted, combined, and rated to produce an overall assessment of riparian health. This assessment method has been widely used in the midwestern United States and in western Canada.

Rating Scheme

The riparian health assessment ratings range from 0% to 100%, with 0% representing an impaired riparian area and 100% representing a healthy riparian area in proper functioning condition (see Hansen et al. 2000).

Riparian Health

Healthy: (Proper functioning condition) (80-100%): Riparian area performs all of its functions and is considered to be stable.

Stressed: (Function at risk) (60-79%): Riparian area performs many functions, but signs of degradation are visible.

Impaired: (Non-functional) (Less than 60%): Riparian area has lost most of its ability to perform its functions and is now considered to be degraded.

Data Source: Between 1996 and 2005 the Saskatchewan Watershed Authority conducted 932 short-form lotic health assessments and 1,290 short-form lentic health assessments. A short-form riparian health assessment provides a rapid snapshot of the health of a riparian area. Long-form riparian health inventories have been conducted in the Upper Qu'Appelle River and the Quill Lakes Watersheds; riparian classification has been done on 312 stands throughout Saskatchewan (Thompson and Hansen 2001). A riparian health inventory is a comprehensive ecological study of a particular site. The inventory documents detailed information about the plant community, soil and hydrology of the site.

Data Quality/Caveats: The site selection process for the riparian health assessments is not always random. Assessments are conducted for a number of reasons, including: a specific study in the area; request for an assessment by the land manager; and to establish baselines for projects. Significant effort is required to determine riparian health and stream stability baselines and trends, as each riparian assessment requires one to two hours per site to complete. Current riparian assessments do not address forestry impacts and issues.

Response to the issue

Sediment deposition caused by the removal of riparian vegetation can impact surface water quality and aquatic habitat. Surface water quality is protected under the Interim Surface Water Quality Objectives (Saskatchewan Environment 2006b). The *Fisheries Act* protects fish habitat from the deposition of deleterious substances, such as sediment. *The Environmental Management and Protection Act, 2002*, regulated by Saskatchewan Environment, controls activities and the disposal of deleterious substances that are harmful to air, land and water resources.

Some of the agricultural Beneficial Management Practices that can improve the health of riparian areas and reduce soil erosion along riparian areas, as promoted by the Environmental Farm Plan in the Guide to the Canada-Saskatchewan Farm Stewardship Program (CSFSP), include:

- riparian area management;
- erosion control structures (riparian); and
- land management for soils at risk.

The Prairie Stewardship Program, a partnership program coordinated by the Saskatchewan Watershed Authority, encourages stewards, through voluntary agreements, to maintain and protect their riparian areas to the best of their ability.

Riparian Buffer Indicator

The issue

Riparian buffers, which are strips of permanent vegetation adjacent to a waterbody, are a widely recommended land management technique to protect source water. Vegetated riparian buffers help perform the essential functions of a healthy riparian area.

The effectiveness of riparian buffers in protecting water quality depends on many factors, including vegetation type, vegetation width, soil type, slope, and adjacent land uses. The majority of factors influencing the effectiveness of riparian buffers are site-specific and usually cannot be quickly assessed. Most scientific research and management recommendations focus on buffer widths to assess the effectiveness of a buffer for protecting water quality.

Riparian Buffer Indicator in Saskatchewan

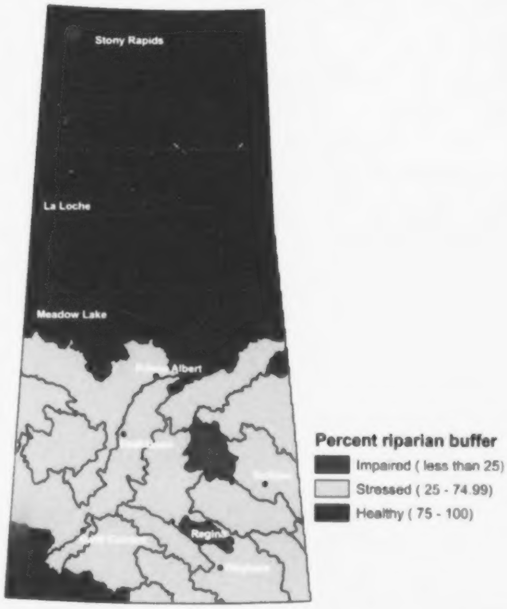


Figure 16. Percent of permanent cover within a 40 metre buffer of a waterway.

The Percent Riparian Buffer width for the majority of Saskatchewan's southern watersheds falls into the stressed or impaired categories, with the exception of the Cypress Hills North Slope and Milk River Watersheds, both of which are rated as healthy. The Quill Lakes Watershed, at 18% riparian buffer, has the least amount of riparian buffer. The Kasba Lake and Beaver River Watersheds had the highest percent permanent cover within the riparian buffer, at 87%.

Buffer width is the sole criterion used to measure Percent Riparian Buffer (i.e. soil type, slope, and vegetation type were not included in the calculation). It is possible that a riparian area with a Percent Riparian Buffer rating of excellent may have a riparian health assessment rating of unhealthy. Therefore, it is important that this indicator be validated with the Riparian Health Indicator. Castelle et al. (1994) identify four criteria for determining appropriate buffer widths: 1) resource value; 2) intensity of adjacent land use; 3) buffer characteristics; and 4) specific buffer functions. Typically, a narrower buffer area may be adequate to protect a waterbody when the riparian area is healthy and the adjacent land use has a low impact potential (i.e. parkland, low density residential, shallow

slopes, or non-erosive soils). Larger buffer areas may be required for high value resources where the riparian area is unhealthy, where soils are less permeable or highly erodible, where slopes are steep, or where the adjacent land use is intense (e.g. intensive agriculture).

Indicator

$$\text{Percent Riparian Buffer} = \frac{\text{Area of permanent cover within a 40 m buffer of a waterway } (m^2)}{\text{Total area of buffer } (m^2)}$$

Rating Scheme

The Percent Riparian Buffer ranges from 0% to 100%, with a value of 0% representing a riparian area that has been cleared of all vegetation within 40 metres of the waterway and 100% representing a riparian area that has permanent vegetative cover throughout the 40 metre buffer.

The rating system is based on studies and literature reviews conducted by Osborne and Kovacic 1993, Castelle et al. 1994, Dosskey 2001, and Broadmeadow and Nisbet 2004.

Percent Riparian Buffer

Healthy: (30 m and over): (PRB value 75 – 100): A buffer width within this range maintains the physical, chemical and ecological components of many wetlands and streams, and has consistently high percent reduction of nutrients, sediment and pesticides.

Stressed: (Between 10-29 m): (PRB value 25 – 74.9): A buffer width within this range has consistently high percent reduction of nutrients, sediment and pesticides, but it is not sufficiently wide to protect the ecological integrity of the waterbody.

Impaired: (Less than 10 m): (PRB value 0 – 24.9): A buffer width within this range is considered unstable and unsustainable. It is unable to provide adequate shade and moderate stream temperatures, and it is highly variable in percent reduction of NO_3^--N, Total N, PO_4^{3-}-P, Total P, sediment and pesticides.

Data Source: The Saskatchewan Stream Network was used to calculate the 40 metre buffer of the streamcourse. The Southern Digital Land Cover and Northern Digital Land Cover classification were used for determining the area of permanent cover within the 40 metre buffer.

Data Handling: The percent permanent cover was measured by drawing a 40 metre buffer on either side of the streamcourse in the Saskatchewan Stream Network. Forage, grassland, shrub, and tree classes from the Land Cover data were lumped together into a class called permanent cover.

Data Quality/Caveats: To reduce the inaccuracies in buffer placement around lakes caused by the Saskatchewan Stream Network, the lake paths were removed from the stream network so as to no longer include large amounts of water within the buffer.

Response to the issue

Sediment deposition caused by the removal of riparian vegetation can impact surface water quality and aquatic habitat. Surface water quality is protected under the Interim Surface Water Quality Objectives (Saskatchewan Environment 2006b). The *Fisheries Act* protects fish habitat from the deposition of deleterious substances, such as sediment. *The Environmental Management and Protection Act, 2002*, regulated by Saskatchewan Environment, controls activities and the disposal of deleterious substances that are harmful to air, land and water resources.

Some of the agricultural Beneficial Management Practices that can improve the health of riparian areas and reduce soil erosion along riparian areas, as promoted by the Environmental Farm Plan in the Guide to the Canada-Saskatchewan Farm Stewardship Program (CSFSP), include:

- riparian area management;
- erosion control structures (Riparian); and
- land management for soils at risk.

The Prairie Stewardship Program, a partnership program coordinated by the Saskatchewan Watershed Authority, encourages stewards, through voluntary agreements, to maintain and protect their riparian areas to the best of their ability.

Permanent Cover Indicator

The issue

Permanent cover is linked to a watershed's capacity to provide a number of functions such as the maintenance of biodiversity, clean water, and reduced flooding potential.

The term "permanent cover" is used to describe patches of native and tame vegetation that are never, or infrequently, cultivated (less than once every 10 years). In southern Saskatchewan, cropland represents the majority of watershed area without permanent cover. While differences exist among types of permanent cover, in general permanent cover in Saskatchewan maintains higher levels of biodiversity and supports more species at risk than cultivated cropland.

While significant relationships between permanent cover and clean water and flood reduction have been demonstrated elsewhere, the relationship between these parameters and the magnitude of their effect have not been investigated in Saskatchewan. Similar relationships between permanent cover and aquatic habitat are possible, but require further research in Saskatchewan. Documentation of critical thresholds for the relationships between permanent cover and these parameters would enable managers to identify and target permanent cover goals appropriate to individual watersheds.

Landscape metrics such as patch size, shape, and connectivity may influence the quality of habitat patches for biodiversity. There is a strong relationship in the southern watersheds between percent permanent cover and mean patch size (Figure 17). Given the ease with which percent permanent cover may be interpreted, its use is preferable.

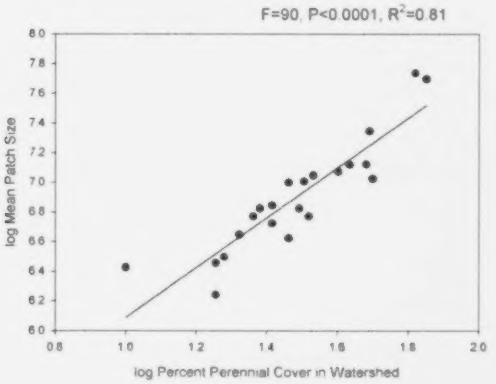


Figure 17. Relationship between percent permanent cover and mean patch size.

Permanent Cover Indicator in Saskatchewan

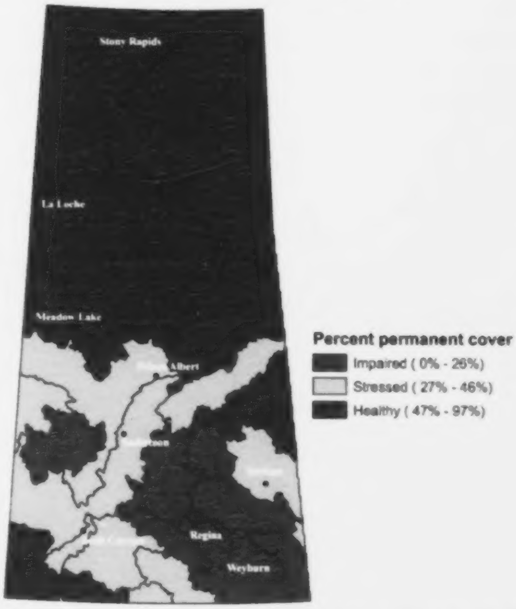


Figure 18. Estimate of percent permanent cover by watershed.

Watersheds with less than 27% of the terrestrial area as permanent cover were designated as having an impaired rating for permanent cover. These watersheds were the Eagle Creek, Lower and Upper Qu'Appelle River, Lower and Upper Souris River, Moose Jaw River, Old Wives Lake, Quill Lakes and Wascana Creek Watersheds.

Global, national and provincial agricultural economic forces and conservation/preservation policies are the major determinants of temporal change in the permanent cover indicator. Conservation (e.g. the North American Waterfowl Management Plan) and preservation (e.g. protected area designation) efforts generally result in small contributions to changes in the permanent cover indicator at a provincial scale, but efforts targeted to specific watersheds may produce measurable change over time.

Indicator

$$\text{Permanent Cover} = \frac{\text{Area of forage (ha)} + \text{Grassland (ha)} + \text{Shrub (ha)} + \text{Tree (ha)}}{\text{Total area of watershed (ha)} - \text{Area of water in watershed (ha)}}$$

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so, the Jenks' optimization method was used to find the natural breaks in the data.

Permanent Cover
Healthy: More than 46% of the watershed area is permanent cover.
Stressed: Between 27% and 46% of the watershed area is permanent cover.
Impaired: Less than 27% of the watershed area is permanent cover.

Data Source: Land cover is derived from the Southern Digital Land Cover classification of 1993-1994 LANDSAT-TM imagery and the Northern Digital Land Cover classification of 2000 LANDSAT-TM imagery at 30 metre resolution.

Data Discussion: Undoubtedly the amount of permanent cover has changed since 1993, likely increasing in many watersheds. Temporal comparisons of permanent cover will not be possible until an update to the Southern Digital Land Cover has been completed. Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Association (AAFC-PFRA) is currently looking at creating an updated land cover classification product using Landsat 7 imagery from 1999-2001 for the agricultural extent of the prairies. Having a more recent product would allow a change analysis to be performed.

Response to the issue

Numerous programs have been initiated to convert marginal annually cropped land to perennial cover (see **Conservation Stewards**). Some of these programs include:

- Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Association's (AAFC-PFRA) Greencover Canada Program – land conversion component;
- Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Association's (AAFC-PFRA) Permanent Cover Program I and II;
- Saskatchewan Watershed Authority's Prairie Stewardship Program;
- Ducks Unlimited Canada's securement programs; and
- Saskatchewan Environment's Conservation Cover Program.

Rangeland Health Indicator

The issue

Rangelands consist of indigenous and/or introduced vegetation that is either grazed or has the potential to be grazed. Healthy rangelands maintain a diversity of plant species, including grasses, herbs, shrubs and trees, through the efficient cycling of nutrients and the capture and slow release of moisture. They also function to improve water quality by reducing sediment deposition and soil erosion (Adams et al. 2005).

Rangeland Health Indicator in Saskatchewan

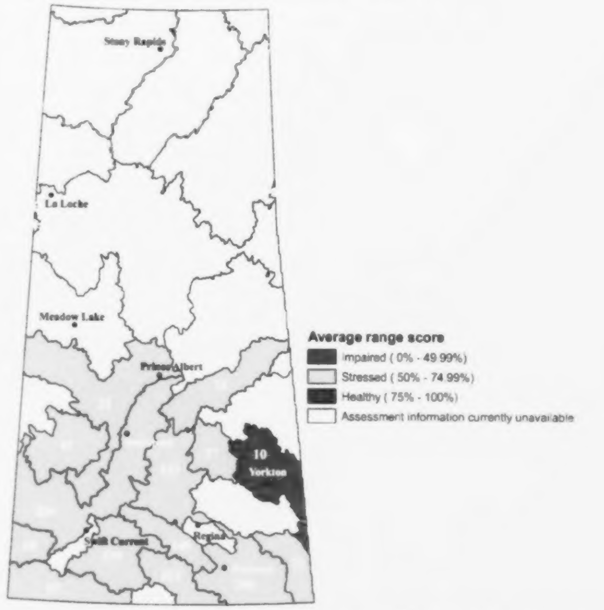


Figure 19. Average native and tame range condition and health scores by watershed.

Note: the numbers shown within the watersheds are the number of assessments used to calculate the average range assessment scores. The range scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Range assessment scores are available for 14 watersheds in Saskatchewan. The average range score for the ranges assessed in the Assiniboine River Watershed were considered impaired. The average range score for the ranges assessed in the other 13 watersheds were considered stressed.

For the purposes of obtaining an average range score for each assessed watershed, range health assessment scores and range condition scores were averaged. The methods used to obtain range condition and range health scores are different. The method used to assess range condition is essentially a partial range health assessment as it only looks at the soil type and plant species composition. In addition to the data collected by the range condition assessments, range health assessments include plant community structure, hydrologic function and nutrient cycling, site stability, and noxious weed information (Adams et al. 2005).

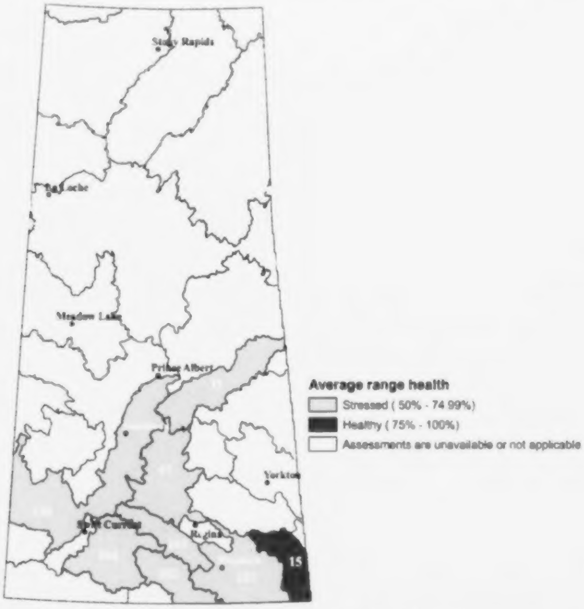


Figure 20. Average native and tame rangeland health assessment scores by watershed.

Note: the numbers shown within the watersheds are the number of assessments used to calculate the average rangeland health assessment scores. The rangeland health assessment scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Currently, information from rangeland health assessments is available for eight watersheds in Saskatchewan. Of the eight watersheds, the ranges in the Lower Souris River Watershed are considered, on average, healthy, and the ranges in the Big Muddy Creek, Carrot River, Moose Jaw River, Old Wives Lake, South Saskatchewan River, Upper Qu'Appelle River, and Upper Souris River Watersheds are considered, on average, stressed.

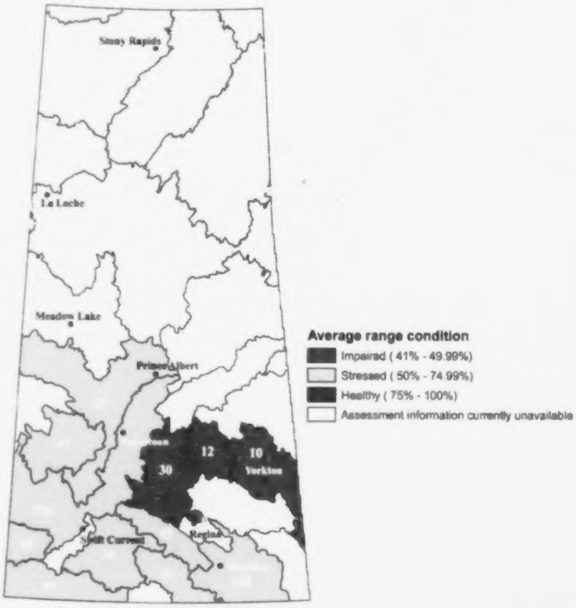


Figure 21. Average native and tame rangeland condition scores by watershed.

Note: the numbers shown within the watersheds are the number of assessments used to calculate the average rangeland condition scores. The range condition scores for watersheds with fewer than 10 assessments were not averaged across the watershed.

Currently, information from range condition is available for 12 watersheds in Saskatchewan. Of the 12 watersheds, the ranges assessed in the Assiniboine River, Quill Lakes, and Upper Qu'Appelle River Watersheds are considered, on average, impaired, and the assessed ranges in the other nine watersheds are considered, on average, stressed.

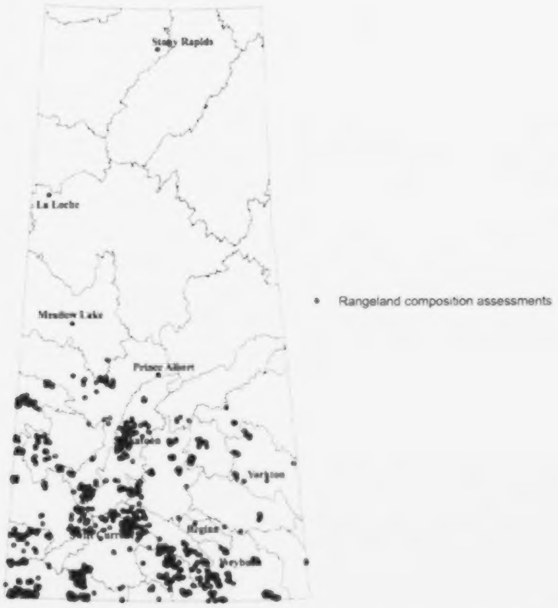


Figure 22. Location of rangeland composition assessments.

Source: Saskatchewan Research Council

Figure 22 summarizes the location of 3,916 rangeland condition assessment sites that have been conducted by a number of agencies. Range condition scores have not yet been calculated for the assessments.

Indicator

Traditionally, rangelands have been evaluated using the Range Condition Method. This method compares the resemblance of the present composition to that of an ecologically desirable composition. In the last few years, range health methods that measure ecosystem function have been widely adopted across North America (Pellant et al. 2000).

Rating Scheme

The rangeland health assessment ratings range from 0% to 100%, with less than 50% representing an impaired range and a score of 75% or more representing a healthy range (see Adams et al. 2005).

Rangeland Health

Healthy: **(A health score of 75 to 100%):** All of the key functions of a health rangeland are being performed.

Stressed: **(A health score of 50 to 74%):** Most, but not all, key functions of a healthy rangeland are being performed.

Impaired: **(A health score of less than 50%):** Few of the functions of a healthy rangeland are being performed.

Data Source: The range scores summarized in Figure 19 are an average of 1,557 range assessments; 936 are rangeland health assessments and 621 are range condition assessments. The rangeland health assessments summarized in Figure 20 are from 936 assessments, of which 744 were conducted by the Saskatchewan Watershed Authority and 192 assessments were conducted by the Canadian Wildlife Service. The range condition assessments summarized in Figure 21 are from 621 assessments that were conducted in 1994 by the Saskatchewan Watershed Authority (formerly the Saskatchewan Wetland Conservation Corporation). Figure 22 contains 3,916 sites that have been assessed for rangeland condition, which were conducted by a number of agencies. Range condition scores have not yet been calculated for the assessments summarized in Figure 22.

Data Quality/Caveats: The site selection process for the rangeland health assessments is not always random. Assessments are conducted for a number of reasons, including: a specific study in the area; request for an assessment by the land manager; and to establish baselines for projects. Most of the rangeland species compositional data available in the province are being compiled by the Saskatchewan Research Council into a single database. This information could be analyzed and used to assess range condition.

Data Discussion: For the last few years range health methods have been informally used to evaluate rangelands in Saskatchewan. Saskatchewan Agriculture and Food's Lands Branch also has an in-house rangeland health assessment that they have been using for a few years.

Through the Prairie Conservation Action Plan (PCAP), nine different Saskatchewan agencies have been working together to adapt Alberta's range health assessment methods (Adams et al. 2005) for Saskatchewan. Once these methods are developed, many agencies within Saskatchewan will be using the same assessment methods [including the Saskatchewan Watershed Authority, Saskatchewan Agriculture and Food, Saskatchewan Environment, the Nature Conservancy of Canada, Ducks Unlimited Canada, the Saskatchewan Research Council (SRC), the Saskatchewan Assessment Management Agency, Nature Saskatchewan, and Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration (AAFC-PFRA)].

The basis of this range health analysis is the ecological site description/community classification (reference conditions). PCAP has obtained funding from the Technical Assistance Component of the Greencover Canada Program for the SRC to develop this site description. Several agencies have pooled data to assist the SRC in developing these ecological site descriptions. The pooled data that are being used to develop these ecological site descriptions will be compiled in a database with thousands of previously assessed sites ranging from the 1950's to present, allowing temporal changes to be observed. Most of the data will be species compositional data only and will not have the other variables needed to assess complete range health. This database will eventually be housed with Saskatchewan Environment. Figure 22 is a summary of this pooled data by location. Range condition scores have yet to be calculated for the assessments summarized.

Response to the issue

Some of the agricultural Beneficial Management Practices that can improve the health of rangelands, as promoted by the Environmental Farm Plan in the Guide to the Canada-Saskatchewan Farm Stewardship Program (CSFSP), include:

- erosion control structures (non-riparian);
- land management for soils at risk;
- grazing management planning; and
- soil erosion control planning.

Environmental Acidification Indicator

The issue

Many industrial and personal activities can result in the emission of compounds containing sulphur and nitrogen which, when deposited to terrestrial and aquatic systems, may result in the acidification of these recipient systems. Production and refining of oil and natural gas, coal- and natural gas-fired power generation, transportation and agriculture are the primary activities in Saskatchewan that lead to the emission of compounds containing sulphur and nitrogen, the precursors of acid deposition and environmental acidification.

Changes in the chemical properties of soil and water occur when acid deposition exceeds the buffering capacity of the receiving system. Such chemical changes may impact nutrient cycling, the biological composition of the system and the functional ability of the system.

Environmental Acidification Indicator in Saskatchewan

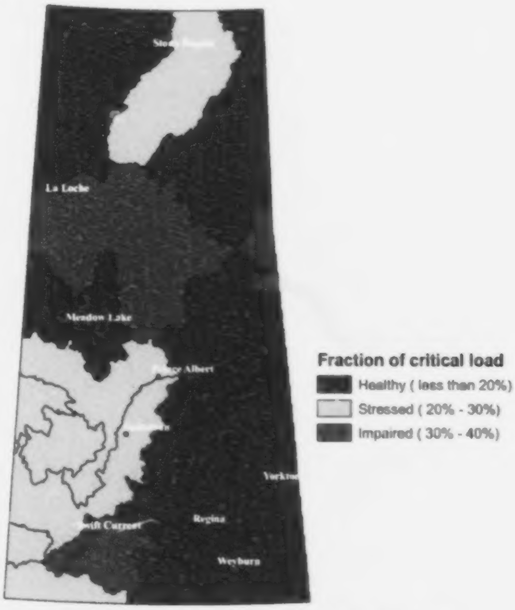


Figure 23. Critical loads for acid deposition by watershed.

The Churchill River, Swift Current Creek and Old Wives Lake Watersheds are the watersheds most impacted by acid deposition in Saskatchewan.

Indicator		
Potential Acid Input (keq H^+ ha^{-1} yr^{-1})	=	Total amount of acidity deposited (keq H^+ ha^{-1} yr^{-1}) – Neutralization capacity (keq H^+ ha^{-1} yr^{-1})
Fraction of Critical Load	=	Potential acid input (keq H^+ ha^{-1} yr^{-1}) / Critical load (keq H^+ ha^{-1} yr^{-1})

Critical Load is 0.25 keq H^+ ha^{-1} yr^{-1} (Alberta Target Loading Sub-Group, CASA, 1999). It is defined (by the Sub-Group) as the numerical expression of the maximum level of deposition that does not lead to long-term, harmful changes to a receptor.

Rating Scheme

Fraction of Critical Load
Healthy: Fraction of critical load is less than 20%.
Stressed: Fraction of critical load is between 20% and 30%.
Impaired: Fraction of critical load is greater than 30%.

Data Source: The Alberta Environment Regional Lagrangian Acid Deposition Model (RELAD) is a three-layer, mass-conserving, regional scale Lagrangian model that simulates ground-level ambient concentrations of acid precipitation (wet and dry). There are three data sets required to run RELAD: the Environment Canada Emissions Inventory (2000) of large point sources (stacks), area sources (urban centers) and linear sources (highways); estimates of each of the various chemical reactions, and rates of reactions, that occur among the acid-forming substances emitted into the atmosphere; and meteorological data (representative year from 1981 – 2005). The data are developed in 1° latitude x 1° longitude grid format, which is then transformed into watershed boundaries.

Data Handling: RELAD provides an estimate of the total amount of acidity deposited in grid cells. Units of deposited acidity are in keq H^+ ha^{-1} yr^{-1}. Co-deposition of base cations (Na^{+2}, Mg^{+2}, Ca^{+2}, and K^{+2}), which reduce acidity, have been corrected for in the deposition numbers. Maps of lake sensitivity data (Ballagh, Saskatchewan Environment, 2001) were used to evaluate neutralization capacity (McDonald and Fox. 1999).

Data Quality/Caveats: This method does not include an estimation of any physical process that moves acidity within the recipient system (leaching, runoff, etc). Results from the model must be considered as best estimates.

Response to the issue

In 2002, Saskatchewan and Alberta signed a Memorandum of Understanding on Acid Deposition Management. The purpose of this agreement is to establish a framework for co-operation between Saskatchewan and Alberta in their respective management of acid-forming substances subject to long-range aerial transport processes between the two provinces. The objectives are: 1) to maximize the efficient use of resources and the effectiveness of both provinces' efforts to monitor and manage the impacts (air, aquatic and terrestrial) of acid deposition; 2) to facilitate the exchange and analysis of environmental data on acid-forming substances, the receiving environment and the impacts of acid deposition; 3) to share perspectives on the environmental effects and appropriate management strategies for acid-forming substances subject to long-range aerial transport; and 4) to manage the release of acid-forming substances subject to long-range aerial transport.

Saskatchewan is also a participant in the implementation of *The Canada-Wide Acid Rain Strategy for Post-2000*. The primary goal of the strategy is to reduce SO^2 emissions to ensure that critical loads for acid deposition are not exceeded within Canada [Federal./Provincial/Territorial Ministers of Energy and Environment (Canada) 1999].

Provincial legislative control of emissions is under *The Clean Air Act*, regulated by Saskatchewan Environment.

Aherne and Watmough (2006) released a report in August 2006 that found that the critical load of sulphur and nitrogen has been exceeded in approximately 2% of the land tested in Saskatchewan.

Species at Risk Indicator (under construction)

The issue

Biodiversity in Saskatchewan is strongly influenced by humans. Some of the broad-scale human activities that impact biodiversity include: habitat disturbance, loss and fragmentation; over-harvesting; introduction of invasive exotic species; climate change; and the release and deposition of pollutants, such as pesticides (Thorpe and Godwin 1999).

Species at Risk Indicator in Saskatchewan

The Saskatchewan Conservation Data Centre has tabulated the number of known flora and fauna species with breeding ranges within a watershed based on elemental occurrence data. An element occurrence is defined as "the spatial representation of a species or ecological community at a specific location. An element occurrence generally delineates a species population or ecological community, and represents the geo-referenced biological feature that is of conservation or management interest. A single element occurrence may be documented by one or multiple specimens or by observations taken from the same population over multiple years" (Saskatchewan Conservation Data Centre 2006b).

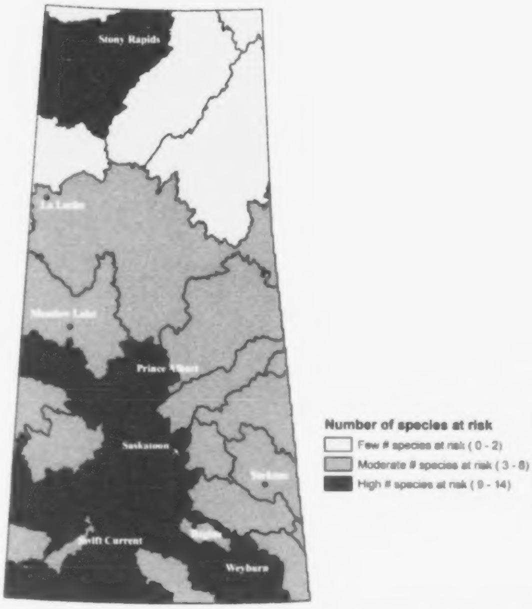


Figure 24. Number of species at risk with breeding ranges that overlap the watershed boundary.

Figure 24 represents the number of species that have a breeding range that is within a given watershed that are endangered, threatened or of special concern as listed in Schedule 1 of the *Species at Risk Act*. "The presence of rare or endangered species in a watershed is not necessarily

Table 4. Number of extinct, extirpated, endangered, threatened and special concern species in Saskatchewan designated by Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and Saskatchewan Conservation Data Centre: May 2005.

Taxonomic group	Extinct	Extirpated	Endangered	Threatened	Special concern
Amphibian	0	0	0	0	2*
Arthropods	0	0	0	3*	1*
Birds	1*	1* (2)	6* (4)	3*	5*
Fish (Freshwater)	0	0	1*	1*	2*
Mammals (Terrestrial)	0	2* (2)	1* (1)	2*	3*
Mosses	0	0	0	1*	0
Reptiles	0	0	0	1*	1*
Vascular Plants	0	0 (1)	2* (4)	4* (1)	9*
Total	**1***	**3* (5)**	**10* (9)**	**15* (1)**	**23***

Source: Saskatchewan Conservation Data Centre
*Source: Committee on the Status of Endangered Wildlife in Canada (COSEWIC), 2005.

an indication of poor watershed conditions. Indeed, it more likely indicates the opposite: in many instances these species persist only in areas of exceptionally high quality habitat. The presence of species at risk in a watershed indicates, however, that these watersheds are especially vulnerable to future water quality or habitat degradation, which could jeopardize the maintenance or recovery of these organisms" (United States Environmental Protection Agency 2006). No significant correlation was found between the number of species at risk within a watershed and the amount of permanent cover by watershed.

Data Source: Data summarized in Table 4 were obtained from the Saskatchewan Conservation Data Centre and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), 2005.

Data Quality/Caveats: The method used by COSEWIC to assess the number of species that are at risk in Canada should be used with caution:

1) Temporal trends cannot be made based on the increasing number of species that are added to COSEWIC's species at risk categories. The increase in the number of species added to the at-risk categories (special concern, threatened, and endangered) is typically a reflection of the pace that species are investigated and designated, and not the speed at which their at-risk status is changing.
2) The inflation of species-at-risk can occur due to COSEWIC's assessment process.
   a) COSEWIC first assesses the entire population of a species, and if necessary will assess a subpopulation of that species. Occasionally, two subpopulations of the same species may both be listed as at-risk.
   b) There are a number of species that are listed as at-risk in Canada; however, Canada represents the northernmost extent of their range.

Response to the issue

Within Saskatchewan, species at risk are regulated by the Species at Risk Act, administered by Environment Canada, *The Wildlife Act, 1998* and *The Wildlife Habitat Protection Act*, regulated by Saskatchewan Environment, and the Accord for the Protection of Species at Risk.

In 1996 Canada's federal, provincial and territorial governments agreed to the national *Accord for the Protection of Species at Risk*. The accord outlines a national commitment to designate species at risk, protect their habitats and develop recovery plans (Environment Canada 2002).

The federal *Species at Risk Act* (SARA) was passed in June 2003. The act is one component of Canada's three-part Strategy for the Protection of Species at Risk that also includes the *Habitat Stewardship Program for Species at Risk* and the *Accord for the Protection of Species at Risk*.

Numerous assessments have been conducted and documents compiled outlining the status of species at risk in Canada (Canadian Endangered Species Conservation Council 2001; and Cannings et al. 2005). In Saskatchewan there are 39 species of wildlife that are at-risk and are designated as extinct (4 species), endangered (13 species), threatened (8 species), and special concern (11 species), as listed in Schedule 1 of SARA.

Once a species is listed as endangered or threatened under SARA, recovery strategies and action plans must be developed. Recovery strategies have been developed and are in the pubic consultation process for three species at risk in Saskatchewan and recovery strategies are currently being developed for five species at risk in Saskatchewan that are listed in Schedule 1 of SARA (Species at Risk Public Registry August 2006).

In Saskatchewan, species at risk are assessed and tracked by both COSEWIC and the Saskatchewan Conservation Data Centre. The Saskatchewan Conservation Data Centre was established in 1992 as a cooperative initiative between the Government of Saskatchewan, The Nature Conservancy (U.S.A), and The Nature Conservancy of Canada. The purpose of the Saskatchewan Conservation Data Centre is to ensure scientific information on plants, animals, and ecological communities in Saskatchewan is reliable, accessible, and current.

Biodiversity monitoring programs that are operating or collecting information on species-at-risk in Saskatchewan include:

- The Forest Management Effects Monitoring Program.
- The Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Created in 1977, the mandate of COSEWIC is to use the best available scientific and Aboriginal traditional knowledge to assess and classify the status of wildlife species in Canada. Once assessed, species are placed into one of seven status categories: extinct, extirpated, endangered, threatened, special concern, not at risk, and data deficient.
- The Habitat Stewardship Program for Species at Risk. The program was initiated in 2000 by the Government of Canada to develop partnerships and stewardship programs to promote and maintain habitat for species at risk.
- The Representative Areas Network.
- Operation Burrowing Owl. Initiated by Nature Saskatchewan in 1987, Operation Burrowing Owl is a stewardship program that promotes the protection of burrowing owl habitat through:
  - monitoring population trends;
  - educating the public; and
  - land stewardship activities to conserve habitat.
- The Rare Plant Rescue Program. Launched by Nature Saskatchewan in 2002, the purpose of the program is to conserve rare plant habitat by working with landowners and providing them with the information they need to make informed stewardship decisions.
- The Piping Plover Guardian Program. The program was created by Nature Saskatchewan in 2002 to increase the productivity of piping plovers in Saskatchewan.
- The Shrubs for Shrikes Program. Established by Nature Saskatchewan in 2003, the Shrubs for Shrikes Program promotes the protection of loggerhead shrike habitat through monitoring, education and habitat conservation.

In 1998, in response to the Canadian Biodiversity Strategy, the Saskatchewan Biodiversity Interagency Steering Committee was established. The purpose of Saskatchewan's Biodiversity Interagency Steering Committee was to oversee the development of a biodiversity action plan for Saskatchewan.

- In 1999, the Government of Saskatchewan released a progress report entitled *Conserving Saskatchewan's Biodiversity* (Government of Saskatchewan 1999).
- In 1999, *Threats to Biodiversity in Saskatchewan* was released by the Saskatchewan Research Council. The document identified, categorized, and ranked the potential threats to biodiversity in Saskatchewan (Thorpe and Godwin 1999).
- In 2000, Saskatchewan's Biodiversity Interagency Steering Committee released the discussion paper entitled *Conserving Saskatchewan's Natural Environment: Framework for a Saskatchewan Biodiversity Action Plan* (Government of Saskatchewan 2000).
- In 2002, Saskatchewan' Biodiversity Interagency Steering Committee released the document entitled *Conserving Saskatchewan's Natural Environment: A Proposed Saskatchewan Biodiversity Action Plan* (Government of Saskatchewan 2002b).
- In 2004, Saskatchewan's Biodiversity Interagency Steering Committee released *Caring for Natural Environments: A Biodiversity Action Plan for Saskatchewan's Future 2004-2009* (Government of Saskatchewan 2004a).
- In 2003, a Saskatchewan Agri-Environmental Scan was conducted to provide a preliminary assessment of the agricultural impacts on soil, air, water and biodiversity. The scan was a joint initiative of federal and provincial departments and agencies, lead by Agriculture and Agri-Food Canada and Saskatchewan Agriculture and Food (Agriculture and Agri-Food Canada and Saskatchewan Agriculture and Food 2003).

In 2003, Saskatchewan Environment developed a document entitled *Activity Restriction Guidelines for Sensitive Species in Natural Habitats* (Saskatchewan Conservation Data Centre 2003). The guide was developed to assist proponents during the planning of proposed projects. The guide informs the proponent of the appropriate setback distance that a project must be from habitat known to be utilized by species at risk. The Saskatchewan Conservation Data Centre distributes the guidelines when a data request is submitted and species at risk are known to occur in the area of the project (http://www.biodiversity.sk.ca/Docs/SKactivityrestrictions-background.pdf).

7.2 Stressor Indicators

Human Population Indicator

The issue

Increases in human population often result in increased demands for infrastructure, such as housing, water, energy, transportation and waste disposal. To accommodate population growth and provide the necessary infrastructure, there are accompanying land use changes and other potential environmental impacts that can affect water quantity and quality (Environment Protection Authority, New South Wales 2003).

Humans are not simply stressors with only negative impacts on environmental quality; they frequently are also responsible stewards. In many cases humans are the dominant driver of ecological structure and function (Pimm 2001). Human population density does not, in itself, cause environmental deterioration; however, it serves as a proxy for the corresponding demands on the environment.

Human Population Indicator in Saskatchewan

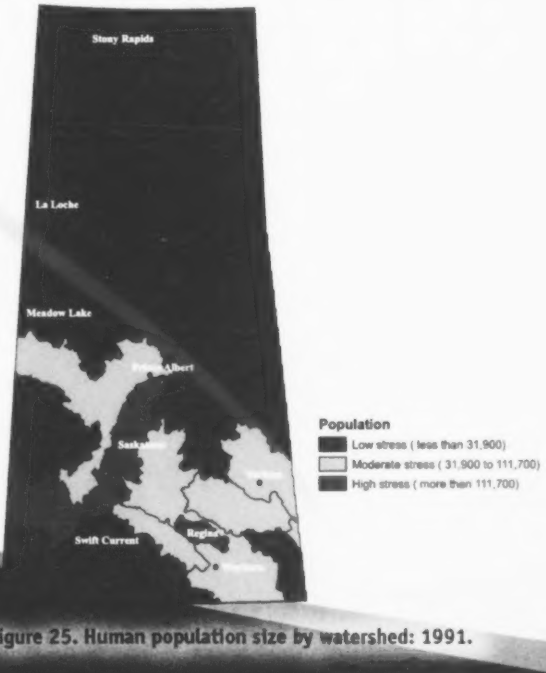


Figure 25. Human population size by watershed: 1991.

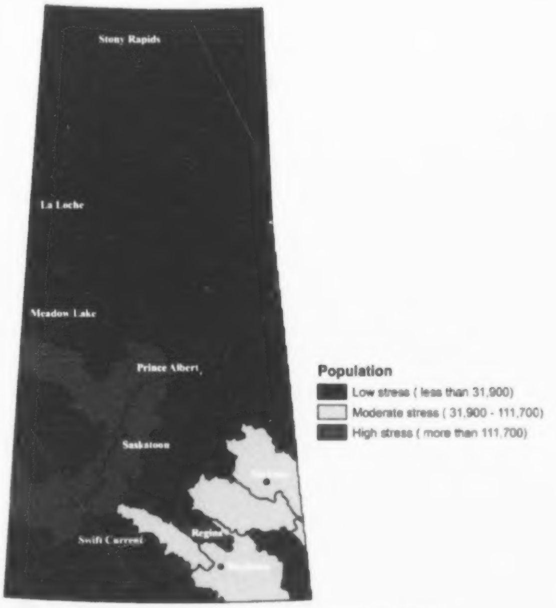


Figure 26. Human population size by watershed: 2001.

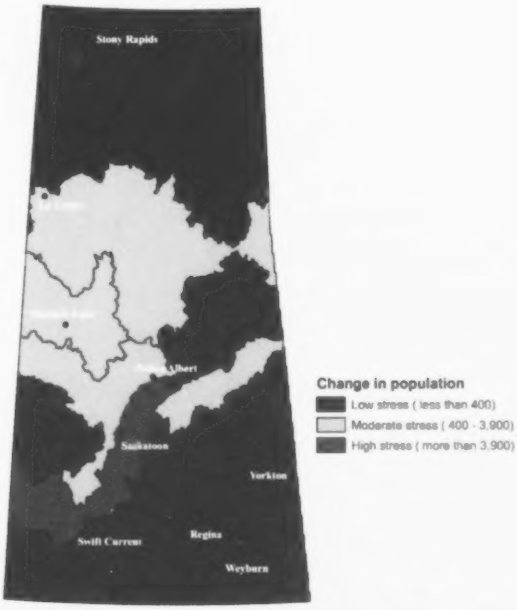


Figure 27. Numerical change in the human population by watershed: 1991 to 2001.

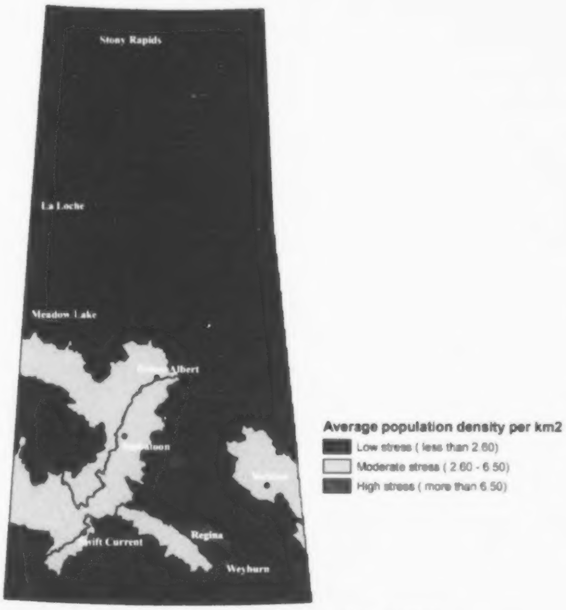


Figure 28. Population density by watershed: 1991.

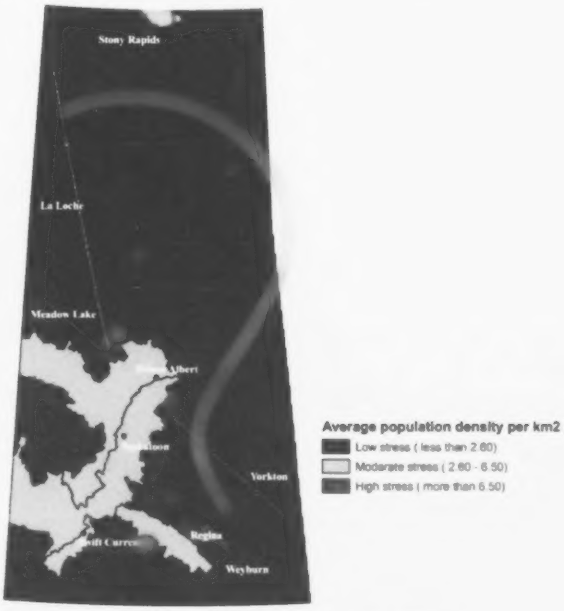


Figure 29. Population density by watershed: 2001.

The total population of Saskatchewan in 2001 was approximately 978,278 people. This is a decline of 8,876 people since 1991. The three most populated watersheds are the Wascana Creek, South Saskatchewan River, and North Saskatchewan River Watersheds (Figure 25 and Figure 26). Population change between 1991 and 2001 was greatest for the South Saskatchewan River and Churchill River Watersheds, which increased by 12,149 and 3,902 people, respectively (Figure 27). Wascana Creek Watershed was the most densely populated with 48.75 people per square kilometre in 1991 (Figure 28) and 48.70 people per square kilometre in 2001 (Figure 29).

Based on population demographics, the Wascana Creek, South Saskatchewan River, and North Saskatchewan River Watersheds are the three most stressed watersheds in the province. Moderately stressed watersheds include the Moose Jaw River, and Swift Current Creek Watersheds.

Indicators		
Population Size	=	Population within a watershed
Population Change	=	$\frac{\text{*Population } t_1 - \text{**Population } t_0}{\text{Population } t_0}$
Population Density	=	$\frac{\text{Population within a watershed (km}^2\text{)}}{\text{Watershed area (km}^2\text{)}}$

*Population t1 = population in 2001.
**Population t0 = population in 1991.

The population within a watershed is calculated by spatially weighting the population by Consolidated Census Sub-Division (CCS) (see Appendix, Figure 82).

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so, the Jenks' optimization method was used to find the natural breaks in the data.

Population Size
Low stress – Population in the watershed is less than 31,900 people.
Moderate stress – Population in the watershed is between 31,900 and 111,700 people.
High stress – Population in the watershed is more than 111,700 people.
Numerical Change in Population
Low stress – Change in population where there are up to an additional 400 people immigrating into the watershed.
Moderate stress – Change in population where there are between 400 and 3,900 people immigrating into the watershed.
High stress – Change in population where there are more than 3,900 people immigrating into the watershed.
Population Density
Low stress – Population density in the watershed is less than 2.60 people/km².
Moderate stress – Population density in the watershed is between 2.60 and 6.50 people/km².
High stress – Population density in the watershed is greater than 6.50 people/km².

Data Source: Population data were obtained from the 2001 Census of Canada (Statistics Canada 2002b).

Data Handling: This measure requires the Statistics Canada census by blocks or Consolidated Census Sub-Division (CCS). Blocks were used to estimate the 2001 population for the following watersheds: Assiniboine River, Big Muddy Creek, Cypress Hills North Slope, Lower Qu'Appelle River, Lower Souris River, Milk River, Moose Jaw River, Old Wives Lake, Swift Current Creek, Upper Souris River, and Wascana Creek Watersheds. The 2001 population for the remaining watersheds was estimated using Census Sub-Divisions.

Data Discussion: Decadal scales are appropriate for assessing temporal watershed population changes. Previous census data would help determine the long-term trend for Saskatchewan. The pre-1991 censuses may be available only at the CCS level. Currently, the Saskatchewan Watershed Authority has access to 1981 population census data but has not acquired previous data. Population census in 1971 may be available in digital format; however, all years prior to 1971 are published and may be represented on a provincial scale only. The Saskatchewan Bureau of Statistics or the Legislative Building will have published information for years previous to 1971, while not charging the fee that Statistics Canada charges.

Response to the issue

The Government of Saskatchewan is involved in the planning and development of human settlements within the province. The response to this issue takes place through legislation, including *The Planning and Development Act, 1983, The Cities Act, The Municipalities Act, The Northern Municipalities Act* and land use planning.

Roads Indicator

The issue

The presence of roads can have physical, chemical, and biological effects on both aquatic and terrestrial ecosystems. Roads can affect the physical processes of ecosystems by increasing soil erosion, water runoff, sediment deposition, altering flow regimes, and turbidity in water bodies (Forman and Alexander 1998). Roads can affect the chemical processes of ecosystems through the transport of pollutants in runoff. The biological impacts of roads include alteration of habitat and habitat fragmentation (Angermeier et al. 2004). Forman and Deblinger (2000) found that various ecological effects of roads extend from at least 100 metres to more than 1 kilometre from the road.

Roads Indicator in Saskatchewan

Figure 30. Road Effect Zone Density by watershed.

The Road Effect Zone Density indicator categorizes 15 of Saskatchewan's 29 watersheds as having high stress potential (Figure 30). The size of the human population within the watershed, the size of the watershed, and the location of the watershed in the province are all factors that influence the Road Effect Zone Density. Watersheds in the northern portion of the province have a very low Road Effect Zone Density and are placed in the low stress category. Most of the watersheds in the southern portion of the province are in the high stress category. The three southern watersheds that are not in the high stress category are the only watersheds in southern Saskatchewan with populations fewer than 5,000 people.

Indicator

$$\text{Road Effect Zone Density} = \frac{\text{Road effect zone (km}^2\text{)}}{\text{Total watershed area (km}^2\text{)}} \times 100$$

The *Road Effect Zone* (REZ) is a method proposed by Forman et al. (1997) to estimate the area ecologically affected by roads. Road Effect Zone Density is the measure of road effects within a watershed.

Assumptions:

1) Road Effect Zone is weighted by road class, with roads classified into primary and secondary roads. A 300 metre buffer for primary roads and a 200 metre buffer for secondary roads is proposed (Forman 2000). Various arguments can be made for revising these buffer distances upwards, downwards, or even not using buffers. The aim was simply to give more weight to wider, more heavily-used roads.

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so, the Jenks' optimization method was used to find natural breaks in the Saskatchewan data.

Road Effect Zone Density

Low stress: Road Effect Zone Density in the watershed is less than 9%.

Moderate stress: Road Effect Zone Density in the watershed is between 9% and 23%.

High stress: Road Effect Zone Density in the watershed is greater than 23%.

Data Source: Road density information was obtained from the National Road Network file, which is approximately 1:10,000 scale.

Data Discussion: Insufficient data from appropriate scientific studies existed to rate this indicator. However, a small number of studies have identified road density thresholds. Road Density (road kilometres/square kilometres) is commonly used in the scientific literature. Road densities above thresholds have the potential to negatively affect various wildlife species; for example:

- 1.24 km/km² caused grizzly bears to be significantly displaced;
- 1.25 km/km² caused black bears to be significantly displaced;
- 0.62 km/km² adversely affected elk; and
- road densities of less than 0.28 km/km² supported strong bull trout populations. Bull trout populations were found to decrease when the road density was 0.87 km/km² or greater, and bull trout populations are typically absent when road densities are 1.06 km/km² (Hammer 2003 and British Columbia Ministry of Water, Land, and Air Protection 2002).

Response to the issue

The Government of Saskatchewan is involved in the planning and development of roads within the province. The response to this issue takes place through legislation and land use planning. Some of the legislation that controls road development includes: *The Highways and Transportation Act, 1997* and *Regulations*, administered by Saskatchewan Highways and Transportation; and *The Planning and Development Act, 1983* (see **Legislative Tools, Strategies Policies, and Guidelines**).

To assist in the planning of transportation systems in Saskatchewan, Saskatchewan Highways and Transportation initiated the development of Area Transportation Planning Committees. The first committee was established in 1995. Committee members include representatives from rural and urban municipalities, Regional Economic Development Authorities, the Saskatchewan Urban Municipalities Association (SUMA), the Saskatchewan Association of Rural Municipalities (SARM), Saskatchewan Highways and Transportation, and other major stakeholder groups in the area (Saskathcewan Highways and Transportation 2006).

In addition to legislation and land use planning, Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration initiated the Prairie Grain Roads Program. The purpose of the program is to improve grain roads and provincial secondary highways used for the transportation of grain. Traffic on these essential roads has increased as a result of changing transportation policies and the restructuring of grain handling systems.

Water Use

Monitoring surface and groundwater use is critical for water conservation strategies and general water management, especially in drier areas. The economic sectors in Saskatchewan that use the most water include agriculture (irrigation and livestock) and communities (municipalities and individuals), which, respectively, are allocated 67% and 21% of the freshwater used in this province (Saskatchewan Watershed Authority 2004).

Surface Water Allocation Indicator

The issue

Surface water allocation is the volume of water licensed by a project that the project is allowed to withdraw. The withdrawal of water from source water bodies is a major component of flow alteration. Flows refer to the pattern, in terms of the quantity and timing, of water moving down a watercourse. The province has long modified flows for domestic, municipal, industrial, and irrigation purposes. Flows in most rivers in southern Saskatchewan are modified to some degree. Flow alteration can impact the water quality and the health of aquatic and riparian ecosystems.

Surface Water Allocation Indicator in Saskatchewan

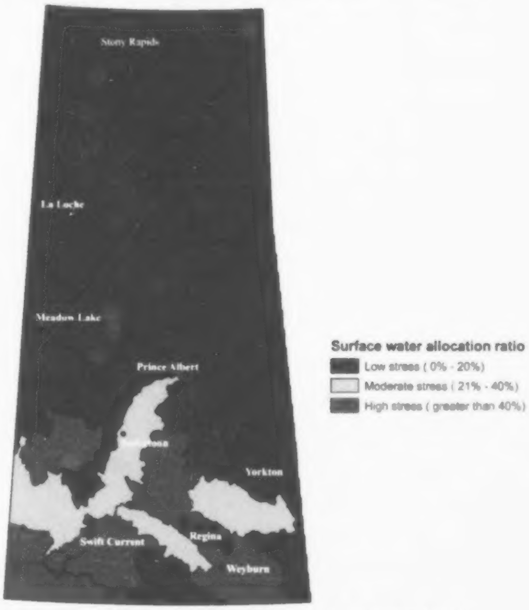


Figure 31. Surface water allocation ratio by watershed.

Nineteen of the watersheds in Saskatchewan currently have a surface water allocation ratio of less than 35%. The watersheds with less than a 35% surface water allocation ratio have the potential to be low to moderate stressors. The Upper and Lower Qu'Appelle River, Moose Jaw River, Quill Lakes, Upper Souris River, Swift Current Creek, Eagle Creek, Old Wives Lake, Milk River, and Cypress Hills North Slope Watersheds all have surface water allocation ratios greater than 40%, which has the potential for placing high stress on these watersheds.

Indicator

$$\text{Surface Water Allocation Ratio} = \frac{\text{Diversion (dam}^3)^*}{\text{Supply (dam}^3)^{**}} \times 100$$

*Diversion is the licensed amount of allocation added to the loss, where the loss represents volume lost due to evaporation and groundwater recharge. Diversion = allocation + loss (evaporation).
**Supply is measured using the estimated calculated median annual flow.

Rating Scheme

The surface water allocation rating scheme takes into consideration the Prairie Provinces Water Board's 1969 Master Agreement on Apportionment. Under this agreement, if a watershed is part of an international or inter-provincial basin the Province of Saskatchewan must provide 50% of the estimated median annual flow to the receiving jurisdiction.

Surface Water Allocation
Low stress: Surface water allocation and losses are less than 20% of the supply.
Moderate stress: Surface water allocation and losses are between 20% and 40% of the supply.
High stress: Surface water allocation and losses are greater than 40% of the supply.

Data Source: Allocation and loses were obtained from the Saskatchewan Watershed Authority's Surface Water Allocation Database, March 2006. Supply is the estimated median annual flow for each major watershed basin (Saskatchewan Watershed Authority 2004).

Data Quality/Caveats: Each year approximately 100 million cubic metres are diverted from the South Saskatchewan River to the Qu'Appelle Basin (which includes the Upper and Lower Qu'Appelle River, Moose Jaw River, Wascana Creek, and Quill Lakes Watersheds). This diversion makes up the difference between the water losses and supply in the Qu'Appelle Basin. Therefore, the supply in the Qu'Appelle Basin is actually 223 million cubic metres, instead of 123 million cubic metres. If the surface water allocation ratio were calculated with the supply of 223 million cubic metres the surface water allocation ratio would be 25.38%, instead of 46.02%. This would change the stress in the respective watersheds from high to moderate.

Data Discussion: Available data do not allow calculation of water use. Instead, what is proposed is to determine the ratio of allocation to supply. Allocation and use are not synonymous: allocation refers to the volume of water that a project is allowed to withdraw; use refers to the volume that is actually withdrawn. Actual water use may be less than that allocated.

Response to the issue

Surface water allocation in Saskatchewan is regulated by the Saskatchewan Watershed Authority, through *The Saskatchewan Watershed Authority Act, 2005*. The Act mandates that the Authority: manage and protect Saskatchewan's source water, watersheds and related lands; promote water conservation; regulate water development and water use; and promote research and conservation programs related to the aforementioned activities.

The Saskatchewan Watershed Authority recognizes the importance of flows for the ecological (physical, chemical and biological) health of streamcourses. Currently, dams are informally and proactively operated to maintain minimum flows for some targeted aspects of ecological health. In addition to maintaining minimum flows, the variability and timing of flows can also be ecologically important. The Authority is currently researching methods of determining and achieving sustainable flows that can best meet watershed health objectives, while maintaining domestic, municipal, industrial, and irrigation water needs.

Groundwater Allocation Indicator

The issue

Groundwater is an integral component of the hydrologic cycle, with the health of watersheds and various associated ecosystems dependent on it. Understanding human groundwater use is important to determine the potential impact humans are having on the health and supply of groundwater (Rutherford 2004). Groundwater is extracted for a number of purposes, including domestic, industrial, municipal, irrigation, and dewatering (e.g. pumping water out of a mine) uses. Through an assessment of groundwater yield, a comparison can be made between the annual allocation rates and the amount of groundwater available for use. There are few aquifer systems (such as the Regina and Yorkton areas) where there are reasonable estimates of the well yield due to the intensive data collection and analysis required in the calculations.

Approximately 440 municipalities in Saskatchewan (including cities, towns, First Nation Reserves, and rural municipalities) rely on groundwater for municipal purposes. The population of these 440 municipalities that rely on groundwater is estimated at 325,211 people, or 33% of Saskatchewan's population.

Groundwater Allocation Indicator in Saskatchewan

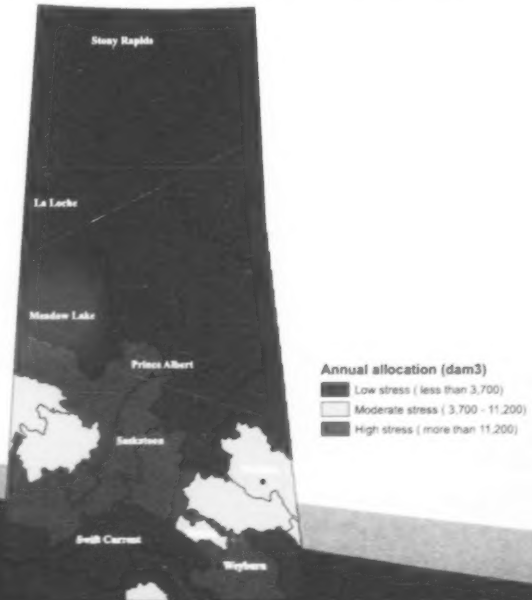


Figure 32. Annual groundwater allocation for projects that are approved for operation by watershed.

The annual allocation of groundwater is greatest for the North Saskatchewan River, South Saskatchewan River, Upper Qu'Appelle River and Upper Souris River Watersheds.

A total of 154,462 dam³ are allocated annually, or are in the approval process for allocation, from groundwater in Saskatchewan. Sixty percent of the groundwater allocations are from the glacial aquifers. The industrial sector constitutes the largest allocation, with 51% of total groundwater allocations. This includes 79,048 dam³, of which 29,650 dam³ is saline water.

Table 5. Annual groundwater allocation by geologic formation.

Formation	Annual groundwater allocation for projects at the application stage (dam³)	Annual groundwater allocation for projects at the approval to construct stage (dam³)	Annual groundwater allocation for projects that are approved for operation/ licensed (dam³)
Athabasca	0	0	1,845
Bearpaw	0	0	567
Blairmore	47	0	19,642
Cypress	0	0	62
Deadwood	0	0	123
Duperow	0	0	202
Empress	200	15	21,199
French/white/east	795	0	132
Glacial	186	9	77,248
Glacial (Condie)	0	0	437
Glacial (Northern)	0	0	2,255
Glacial (Regina)	0	0	7,173
Glacial (Zehner)	1	0	5,170
Judith	0	37	8,712
Jurassic	0	0	529
Lea Park	0	0	92
Mississippian	0	0	507
Other	0	0	89
Ravenscrag	1	0	2,572
Ribstone	0	0	2,235
Roseray	0	0	598
Unknown	0	0	16
Viking	0	0	10
*	706	371	680
Total	**1,935**	**432**	**152,096**

*Aquifer has not been identified

Table 6. Annual groundwater allocation by use category.

Purpose	Annual allocation (dam^3)	Percent of annual allocation
Industrial	79,048	51%
Municipal	70,178	45%
Irrigation	2,591	2%
Other	2,394	2%
Domestic	136	0%
Multi-purpose	116	0%
Total allocation	**154,462**	**100%**

* Domestic wells are not pursuant to *The Saskatchewan Watershed Authority Act, 2005* and do not require approval for the groundwater works unless the water is used away from the home quarter. The annual domestic allocation of 136 dam^3 listed in Table 6 is for wells located away from the home quarter which do require approval.

Indicator		
Groundwater Allocation	=	Annual approved groundwater allocation for projects (dam^3/yr)

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so, the Jenks' optimization method was used to find the natural breaks in the data.

Groundwater Allocation
Low stress: Groundwater allocation is less than 3,700 dam^3/yr.
Moderate stress: Groundwater allocation is between 3,700 and 11,200 dam^3/yr.
High stress: Groundwater allocation is greater than 11,200 dam^3/yr.

Data Source: Groundwater allocation data were obtained from the Saskatchewan Watershed Authority's Licensed Ground Water Database, July 2006. Population data were obtained from the online Saskatchewan Health Covered Population 2004 report published by Government of Saskatchewan (2004b) (http://www.health.gov.sk.ca/mc_dp_covpop2004/main.htm).

Data Handling: Data on the population of cities, towns, First Nation Reserves and rural municipalities reliant on groundwater were imported into MS Access and linked to 2004 Saskatchewan Health data (Government of Saskatchewan 2004b). When 2004 Saskatchewan Health data were unavailable for the city, town, First Nation Reserve or rural municipality, population information was obtained from older Saskatchewan Health data, or Statistics Canada (Statistics Canada 2002b).

Data Quality/Caveats: The basin and sub-basin fields in the Licensed Ground Water Database are based on drainage boundaries, not geologic formation boundaries. A comparison of the watershed and drainage basin map boundaries needs to be conducted to determine the allocation information for a watershed. Annual groundwater allocation is the amount of groundwater allowable for extraction; it is not the actual amount the project uses. Actual annual extraction information is not typically reported, and therefore it is not included in the Licensed Ground Water Database. Groundwater allocations from domestic wells within the home quarter are not included in Table 6. Domestic wells are not pursuant to *The Saskatchewan Watershed Authority Act, 2005* and do not require approval for the groundwater works unless the water is used away from the home quarter.

Data Discussion: At present the population reliant on groundwater is summarized for the whole province.

Response to the issue

The primary response to ensure sustainable groundwater allocation in Saskatchewan is through groundwater licensing.

Groundwater allocation is regulated by the Saskatchewan Watershed Authority, through *The Saskatchewan Watershed Authority Act, 2005* and *The Ground Water Regulations*.

The Saskatchewan Watershed Authority Act, 2005 mandates that the Authority: manage and protect Saskatchewan's source water, watersheds and related lands; promote water conservation; regulate water development and water use; and promote research and conservation programs related to the aforementioned activities.

The Ground Water Regulations controls the exploration and use of groundwater through the establishment of a permit system. The regulations set out requirements that the owner and driller must comply with, including registering machinery, submitting drilling records, well disinfection and construction methods, test hole abandonment procedures, and licensing and use of groundwater.

Under the Act, all groundwater use except for domestic purposes requires an approval. The Saskatchewan Watershed Authority's regulatory approval process for development of a groundwater source project requires that the proponent of a groundwater development obtain:

1) a Ground Water Investigation Permit; and
2) an Approval to Construct and Operate Works and Water Rights Licence to Use Ground Water.

Aquatic Fragmentation Indicator

The issue

Upstream and downstream ecosystems can be ecologically impacted by intersecting barriers or control structures such as dams, weirs, drop structures, and other man-made systems which modify hydrologic flow. Some of the potential positive or negative environmental impacts include: altered flow regimes; altered biogeochemical cycles; changes in water temperature; altered riparian communities due to changes in flooding patterns; and changes in habitat and migration patterns of fish and other aquatic species (Dynesius and Nillson 1994). According to the World Commission on Dams (2000), flow pattern is the most important factor affecting the structure and integrity of downstream aquatic ecosystems. The Commission found that aquatic communities in rivers with a naturally variable flow are typically distinct from those communities in rivers with a highly regulated flow. Another significant impact of dams is that they impede the migration and dispersal of aquatic species. Research has found that localized extinction of some freshwater organisms can be directly linked to aquatic fragmentation caused by dams (Gehrke et al. 2002).

Aquatic Fragmentation Indicator in Saskatchewan

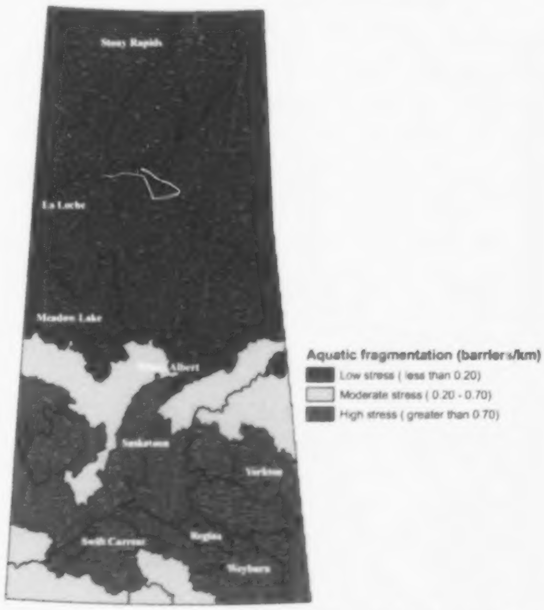


Figure 33. Aquatic fragmentation in the watersheds of Saskatchewan.

Aquatic fragmentation has the potential for placing high stress on fifteen of Saskatchewan's twenty-nine watersheds. Relative to other watersheds, the northern watersheds are characterized by low aquatic fragmentation potential.

Indicator	
Aquatic Fragmentation	= [(3 × # of dams) + (2 × # of stream/road crossings) + (2 × # of low-level crossings) + (# of bridges)] / Length of waterway

Weighting was used to capture the relative difference in impacts between the various forms of aquatic barriers, with dams predicted to have the most impact and bridges and surface water projects the least.

Stream/road crossings are not known physical barriers; rather they represent the number of intersections between the Saskatchewan National Road Network and the Saskatchewan Stream Network and the number of intersections between the railroads file and the Saskatchewan Stream Network. There will be some redundancy between the stream/road crossing parameter and the other parameters used in this calculation.

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so, the Jenks' optimization method was used to find the natural breaks in the data.

Aquatic Fragmentation
Low stress: Aquatic fragmentation is less than 0.20 barriers/km.
Moderate stress: Aquatic fragmentation is between 0.20 and 0.70 barriers/km
High stress: Aquatic fragmentation is greater than 0.70 barriers/km.

Data Source: Dam locations are from the National Topographic Database and the land location of the Saskatchewan Watershed Authority's dams. The Saskatchewan Stream Network was used to intersect with roads and railroads to estimate the number of stream road crossings. Saskatchewan Highways and Transportation databases were used for low-level crossings and bridges.

Data Discussion: Future analysis is dependant on the availability of data and will, therefore, be a function of when the databases are updated; however, the possibility of using previous National Topographic System information with the land locations of structures could provide temporal analysis.

Response to the issue

The Saskatchewan Watershed Authority regulates the construction, extension, alteration and operation of any works (e.g. dykes, dams, weirs, floodgates, breakwaters, reservoirs, canals, tunnels, bridges, and culverts) in Saskatchewan through *The Saskatchewan Watershed Authority Act, 2005*. The Saskatchewan Watershed Authority also regulates development along shorelines in reservoirs under *The Reservoir Development Area Regulations*.

In addition to legislation, habitat enhancement programs have also been initiated to reduce the impact of aquatic fragmentation. These programs include:

- A partnership project between Fisheries and Oceans Canada, the Saskatchewan Wildlife Federation, and the Saskatchewan Watershed Authority to assess the biological impacts of identified impediments to fish passage. Once the biological impacts of the impediments have been assessed, plans will be developed to reduce or eliminate those impacts. The primary focus of this project is on fish habitat and improving fish access.
- The Saskatchewan Watershed Authority conducts wildlife habitat assessments on lands surrounding the Rafferty and Alameda reservoirs. These assessments are conducted as mitigation of habitat loss, which was required by both the federal and provincial governments for the federal license to construct to proceed.

Potential Spring Runoff from Urban Impervious Areas Indicator

The issue

Approximately 64% of Saskatchewan's population resides in urban areas (Statistics Canada 2002b). As the urban population grows there is increasing demand to develop infrastructure such as roads and housing, thereby increasing impervious areas. Impervious surfaces such as roads, parking lots, sidewalks, driveways and roofs prevent precipitation from infiltrating the soil. Runoff from impervious areas can negatively impact the health of watersheds by: 1) increasing the volume and velocity of runoff, causing changes in watershed hydrology; and 2) increasing pollutant loadings, which affects water quality. Possible impacts associated with changes in hydrology include flooding, aquatic habitat degradation and the displacement of aquatic species. Pollutants in stormwater runoff can have harmful effects on drinking water supplies, recreational use and wildlife. Ubiquitous urban stormwater pollutants include sediments, motor oil, nutrients from fertilizers and pet waste, microbes, toxic metals, and various organic compounds such as herbicides and pesticides. Schueler (1994) reviewed studies examining the relationship between urbanization and stream quality. He found that once watersheds have more than ten percent impervious area there is often: 1) an increase in the volume of surface runoff; 2) an alteration of stream banks due to increased flows and erosion; and 3) a decrease in aquatic habitat quality resulting in declines in fish and aquatic insect diversity.

Potential Spring Runoff from Urban Impervious Areas Indicator in Saskatchewan

Figure 34. Average spring runoff from impervious areas as a percent of spring flow: 2000 to 2005.

The Wascana Creek and Upper Souris River Watersheds have calculated spring runoff from impervious areas that contribute greater than 20% of the spring flow. The South Saskatchewan River, Assiniboine River and Lake Winnipegosis Watersheds have spring runoff from impervious areas that contributes between 2% and 20% of the spring flow.

Urban runoff water quality studies were conducted for the City of Saskatoon (Munch and Keller 1985; and McLeod et al. 2004) during the summers of 2001 and 2002. McLeod et al. (2004) found that concentrations of cadmium, chromium, copper, iron, lead, and zinc in Saskatoon's urban runoff exceeded Canadian Council of Ministers of the Environment's guidelines for the protection of freshwater aquatic life.

Indicator				
Potential Spring Runoff for Urban Impervious Areas	=	Urban impervious area (m^2)	x	Precipitation (m)
Percentage of Spring Flow Associated with Spring Runoff	=	$\frac{\text{Potential spring runoff for urban impervious areas}}{\text{Spring flow}}$	x	100

- The impervious cover of the major urban cities (>5,000 people) in Saskatchewan was estimated to be 35%, which is a conservative estimate (Perkins 2004).
- Precipitation data used were for the months from October to the end of May.
- Spring flow data were calculated for the months of March until the end of May.

Assumptions:

- All winter precipitation is effective in producing runoff.
- Observed precipitation at meteorological stations is equal to the precipitation within adjacent urban areas.

Rating Scheme

Potential Spring Runoff From Urban Impervious Areas
Low stress: Percentage of spring flow potentially associated with spring runoff is less than 2%.
Moderate stress: Percentage of spring flow potentially associated with spring runoff is between 2 and 20%.
High stress: Percentage of spring flow potentially associated with spring runoff is greater than 20%.

Data Source: Urban area boundaries were obtained from Information Services Corporation's Cadastral Dataset. Precipitation data were obtained from Environment Canada's online climate data (http://www.climat.meteo.ec.gc.ca/climateData/canada_e.html). Flow data were obtained from the Water Survey of Canada (http://www.wsc.ec.gc.ca/). Hydrometric flow data used for the calculations of this indicator are from the Water Survey of Canada (2005): Station ID: 05MB001, 05MB003, and 05MD004 (Assiniboine River Watershed), 05LC001 (Lake Winnipegosis Watershed), 05JK007 (Lower Qu'Appelle River Watershed), 05JE006 (Moose Jaw River Watershed), 05EF001 and 05GG001 (North Saskatchewan River Watershed), 05GG01 and 05HG001 (Saskatchewan River Watershed), 05HG001 (South Saskatchewan River Watershed), 05HD039 (Swift Current Creek Watershed), 05JF001 (Upper Qu'Appelle River Watershed), 05NB011 (Upper Souris River Watershed), and 05JF005 (Wascana Creek Watershed). All hydrometric flow data are from hydrometric stations downstream of the major urban centres within the watersheds.

Data Handling: The areas of urban centres were multiplied by 0.35, a conservative estimate of imperviousness within these urban centres. (Perkins 2004).

Data Quality/Caveats: This land classification is not equivalent to impervious area, but it is correlated and provides the best estimate from available data sources. The percentage of spring flow associated with spring runoff was calculated for eleven of the twenty-nine watersheds. The indicator was not calculated for the remaining eighteen watersheds as either the hydrometric data were unavailable or there were no urban centres that bordered waterways.

Response to the issue

Most aspects of stormwater are not currently specifically regulated under *The Environmental Management and Protection Act, 2002* or *The Water Regulations, 2002* (Saskatchewan Environment 2006c). To address this gap in legislation Saskatchewan Environment published a Stormwater Guidelines document. The purpose of the guidelines are to provide "technical guidance to municipal authorities, individuals and consultants who plan to develop and implement drainage systems for stormwater in urban/built-up municipal areas, commercial and industrial areas in Saskatchewan" (Saskatchewan Environment 2006c).

Municipal Wastewater Effluent Discharge Indicator

The issue

Municipal wastewater effluent is one of the largest origins of point-source pollution to surface water in Canada (Environment Canada 2004). Effluent typically contains high concentrations of nitrogen and phosphorus, which can lead to eutrophication in receiving waterbodies. At high concentrations some nutrients can also be toxic to aquatic organisms. This is especially true of total ammonia nitrogen. Saskatchewan's objective for unionized ammonia in surface water is 19 µg/L, which, depending on pH and temperature, can be exceeded downstream of effluent discharges. Smaller receiving waterbodies with low relative flows are at greater risk of eutrophication and/or toxic effects due to the lower dilution and dispersion potential. There were 617 regulated wastewater works in Saskatchewan in 2002 (Saskatchewan Environment 2004a). These are listed in Saskatchewan Environment regulatory records under *The Environmental Management and Protection Act, 2002* within *The Water Regulations, 2002*. The level of wastewater treatment affects the type and concentration of pollutants in the discharged effluent. The dilution potential of the receiving waters is determined by the volume or flow. A watershed with a large water supply has a greater ability to dilute pollutants contained within the effluent than does a watershed with a low water supply. As a preliminary indicator for assessing the potential stress of municipal wastewater effluent discharges on watersheds we are looking at the municipal population of the watershed divided by the annual river flow (surface water supply) within the watershed.

Municipal Wastewater Effluent Discharge Indicator in Saskatchewan

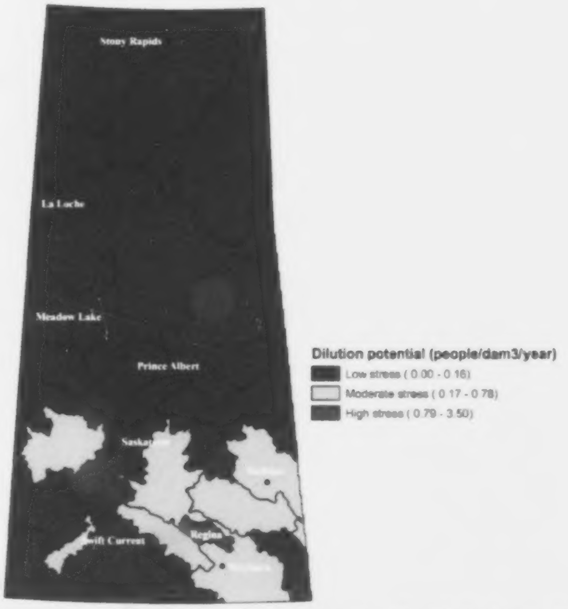


Figure 35. Dilution potential of wastewater effluent discharges by receiving watersheds.

The dilution potential of the Wascana Creek Watershed is low, ranking it as the watershed with the highest potential stress in Saskatchewan. Seven other Saskatchewan watersheds, including the: Assiniboine River, Eagle Creek, Lower Souris River, Lower Qu'Appelle River, Moose Jaw River, Swift Current Creek and Upper Qu'Appelle River Watersheds, have moderate dilution potentials, ranking them as having a moderate stress potential. All other watersheds have high dilution rate and therefore a low stress potential.

Indicator		
Dilution Potential of Wastewater Effluent Discharged	=	$\dfrac{\text{Total municipal population within the watershed}}{\text{Annual surface water supply for the watershed (dam}^3\text{)}}$

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to identify the natural breaks in the data.

Assimilative Capacity of Wastewater Effluent Discharged
Low stress: Population within the watershed is less than 0.17 people/dam³/year.
Moderate stress: Population within the watershed is between 0.17 and 0.78 people/dam³/year.
High stress: Population within the watershed is greater than 0.78 people/dam³/year.

This indicator will eventually report on the annual percentage of the municipal wastewater effluent loading from urban wastewater treatment plants relative to the background load of nutrients in the receiving water.

Table 7. Total annual phosphorus and ammonia-N loading from the City of Yorkton.

Year	Average annual phosphorus concentration (g/m^3)	Average annual ammonia-N concentration (g/m^3)	Total annual volume of wastewater discharged (dam^3/year)	Total annual phosphorus loading (kg P/year)	Total annual ammonia-N loading (kg N/year)
2001	5.12	18.30	2,468	12,608	45,793
2002	4.95	14.51	2,321	12,211	32,781
Average	**5.03**	**16.41**	**2,394.5**	**12,409**	**39,287**

Table 8. Total annual upstream loading of phosphorus and ammonia-N.

Year	Total annual upstream phosphorus loading (kg P/year)	Total annual upstream ammonia-N loading (kg N/year)	Phosphorus load from municipal wastewater as a percentage of the upstream nutrient load	Ammonia-N load from municipal wastewater as a percentage of the upstream nutrient load
2001	4,584	2,572	275%	1,781%
2002	500	236	2,440%	13,919%
Average	**2,542**	**1,404**	**1,358%**	**7,850%**

The wastewater nutrient loading example provided for the City of Yorkton is somewhat unique because the city's wastewater treatment plant discharges into a relatively small stream that has little to no natural flow during the winter. Because the wastewater treatment plant has a relatively consistent outflow, this results in high nutrient loading compared to the small receiving stream. On an average annual basis the nutrient load from the City of Yorkton's wastewater treatment plant is greater than the natural nutrient load. This means that the total phosphorus and total ammonia from the city exceeds the natural load by more than 100%. In other cities, such as Saskatoon, effluent is discharged into a large river with high flow, thus the relative loading from the city is small compared to Yorkton.

Data Source: Population data were obtained from the 2001 Census of Canada (Statistics Canada 2002b). River flow data were obtained from the Saskatchewan Watershed Authority.

Concentrations of phosphorus and ammonia-N in the wastewater discharged and the volume of wastewater discharged from the H.M. Bailey Water Pollution Control Plant in Yorkton are from the City of Yorkton. Flow data were obtained from the Water Survey of Canada (http://www.wsc.ec.gc.ca/). Hydrometric flow data for the City of Yorkton are from the Water Survey of Canada (2005), Station ID: 05MB001 (Yorkton Creek near Ebenezer).

Indicator

Total Annual Nutrient Loading from Municipal Wastewater Discharge	=	Average concentration of nutrient × Volume discharged
Nutrient load from Municipal Wastewater as a Percentage of the Upstream Nutrient Load	=	$\frac{\text{Total annual nutrient loading from municipal wastewater discharge}}{\text{Upstream nutrient load}} \times 100$
Wastewater Treatment Plant Density by Watershed	=	$\frac{\text{Number of wastewater treatment plants}}{\text{Total watershed area (1,000 km}^2\text{)}}$

Response to the issue

The Water Regulations, 2002, administered by Saskatchewan Environment under *The Environmental Management and Protection Act, 2002*, regulates the operations and reporting of municipal water treatment and wastewater treatment facilities. Wastewater effluent quality from each of the regulated wastewater works is reviewed and monitored by Saskatchewan Environment.

The Plumbing and Drainage Regulations, administered by Saskatchewan Health through the local health authority, regulate private sewage systems.

Livestock Indicator

The issue

Manure from livestock operations can impact water quality by increasing nutrients and pathogen loading. Nutrient loading from manure can contribute to eutrophication of surface water and increase the concentration of nitrate in groundwater. Diseases from microorganisms found in livestock manure, including bacteria and protists (such as Giardia and Cryptosporidium), are also a concern. Humans can contract these diseases through direct contact with or consumption of contaminated water (Miller 2001).

Livestock Indicator in Saskatchewan

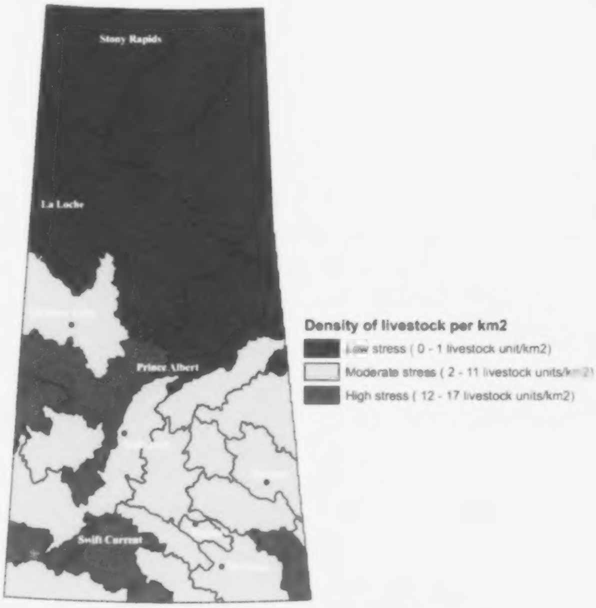


Figure 36. Density of livestock per watershed: 2001.

Density of livestock is greatest in the Battle River, Cypress Hills North Slope, Lower Souris River, North Saskatchewan River, Old Wives Lake, Poplar River and Swift Current Creek Watersheds.

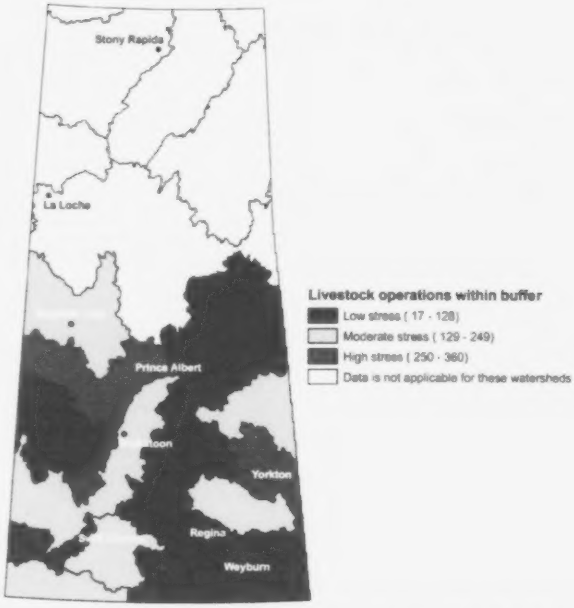


Figure 37. Relative risk of livestock operations within 300 metres of a streamcourse.

The Assiniboine River and North Saskatchewan River Watersheds both have more than 249 livestock operations within 300 metres of a waterway, resulting in them being classified as having the potential for high stress.

Indicator				
Density of Livestock	=	$\dfrac{\text{Number of livestock [animal unit equivalents (AUEs)] per watershed}}{\text{Total watershed area (km}^2\text{)}}$		
Livestock Operations Within 300 m of Streamcourse*	=	$\dfrac{\text{Watershed area within 300 m of a streamcourse (m}^2\text{)}}{\text{Total watershed area (m}^2\text{)}}$	x	Number of livestock operations

Assumptions:

- *Livestock operations have an equal chance of being distributed throughout a watershed.
- *The chance of being located near a watercourse increases with the length of streamcourse in a watershed. This is a conservative assumption; in reality, livestock operations have a tendency to be located closer to streamcourses.

Livestock operations within 300 metres of a streamcourse are one trigger for *The Agricultural Operations Act*.

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to find the natural breaks in the data.

Livestock Density

Low stress: Density of livestock is less than two animal unit equivalents (AUEs) per square kilometre.

Moderate stress: Density of livestock is between two and 11 animal unit equivalents (AUEs) per square kilometre.

High stress: Density of livestock is more than 11 animal unit equivalents (AUEs) per square kilometre.

Livestock Operations

Low stress: The estimated number of livestock operations within 300 metres of a streamcourse is less than 129.

Moderate stress: The estimated number of livestock operations within 300 metres of a streamcourse is between 129 and 249.

High stress: The estimated number of livestock operations within 300 metres of a streamcourse is greater than 249.

Data Source: The number of livestock operations is from the 2001 Census of Agriculture (Statistics Canada 2002a). The Saskatchewan Stream Network was used to calculate the watershed area within 300 metres of a streamcourse.

Data Quality/Caveats: To reduce the inaccuracies in buffer placement around lakes caused by the Saskatchewan Stream Network, the lake paths were removed from the stream network.

Data Discussion: This indicator could be calculated using data from other agricultural censuses on a five-year basis to derive temporal trends.

Response to the issue

Livestock operations are regulated in Saskatchewan by *The Agricultural Operations Act*, which is administered by Saskatchewan Agriculture and Food. *The Agricultural Operations Act* contains two mandates: to provide nuisance provisions and to provide intensive livestock provisions.

To reduce the environmental risk of livestock operations in Saskatchewan, the federal and provincial governments promote Beneficial Management Practices through the Canada-Saskatchewan Farm Stewardship Program. Beneficial Management Practices related to livestock operations include:

- improved manure storage and handling;
- manure treatment;
- manure land application;
- in-barn improvements;
- relocation of livestock confinement and horticultural facilities;
- wintering site management; and
- nutrient management planning.

A number of monitoring programs have been established across the province to assess the impact of intensive livestock operations on water quality. Some of these monitoring programs include:

- The Spring Runoff Water Quality Program, initiated in 1998 by Saskatchewan Agriculture and Food in partnership with Saskatchewan Environment. The purpose of the program is to monitor select intermittent watercourses adjacent to fields fertilized with manure to investigate the potential impacts on water quality (Saskatchewan Agriculture and Food 2003a).
- Saskatchewan Agriculture and Food also monitors the function of several intensive livestock operations in the province. Monitoring activities include collecting water samples from the intensive livestock operation and surrounding fields to ensure that they meet provincial water quality standards (Saskatchewan Agriculture and Food n.d.).
- The Spirit Creek Watershed Monitoring Project, initiated in 2000 by the Spirit Creek Watershed Monitoring Committee. The purpose of the project is to monitor the environmental effect of intensive livestock operations on soil, water and air quality in the Spirit Creek Watershed, a sub-basin of the Assiniboine River Watershed.

Agricultural Non-Point Sources

Agricultural activities are widespread and have intensified over time throughout the southern prairies. Cropping practices, livestock grazing, manure application and agricultural inputs can all contribute to non-point source pollution.

An appropriate indicator for assessing non-point source pollution is a general non-point source pollution model. The development of such a model is a priority for State of the Watershed Reporting and for meeting Branch and Division objectives within the Saskatchewan Watershed Authority. However, until such a model is developed, four substitute metrics can be used: Livestock Density, Fertilizer and Pesticide Inputs, Manure Application and Soil Erosion (Condition indicator).

At this point multiple indicators are recommended for capturing the wide range of impacts that agricultural land management practices have on water quality. Ultimately these should be incorporated into a non-point source model.

Soil Erosion Indicator

The issue

Soil erosion is one of the primary causes of agricultural non-point source pollution, and is an important mechanism by which surface water may be impacted by agricultural land management. Sediment deposition caused by soil erosion can affect surface water quality and aquatic habitat. Some of the physical and chemical impacts of soil erosion to surface water include increased turbidity and increased loading of nutrients, especially nitrogen and phosphorus. It should be noted that not all soil lost to wind, water and tillage is delivered to waterways and waterbodies. The majority of the eroded soil is redistributed within the landscape.

Soil Erosion Indicator in Saskatchewan

The information used to calculate this indicator was obtained from the Soil Erosion Chapter of the *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series – Report #2* (Lefebvre et al. 2005).

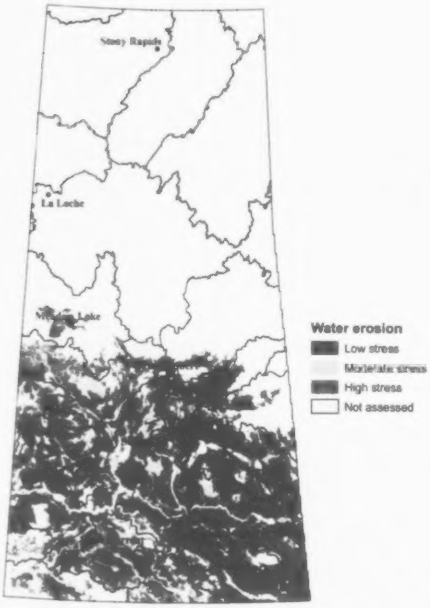


Figure 38. Water erosion risk of annually cultivated soils at a Soil Landscape basis with the watershed boundary overlay.

Data Source: van Vliet et al. 2005.

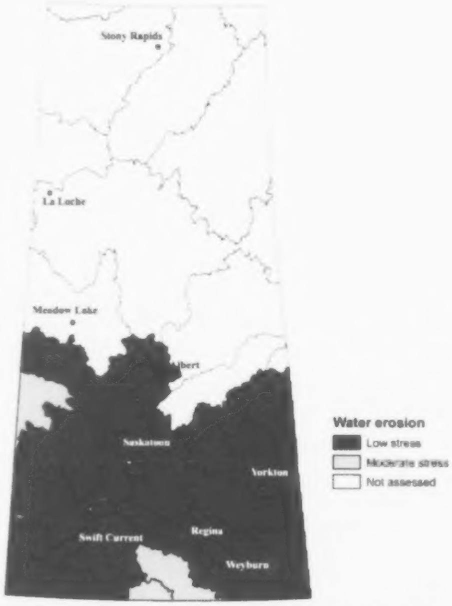


Figure 39. Water erosion risk of annually cultivated soils by watershed: 2001.

Data Source: van Vliet et al. 2005.

Agricultural Non-Point Sources

Soil Erosion Indicator

The Issue

Soil Erosion Indicator in Saskatchewan

Figure 38. Water erosion risk of annually cultivated soils at a Soil Landscape basis with the watershed boundary overlay.

Figure 39. Water erosion risk of annually cultivated soils by watershed: 2001.

Of the land assessed for water erosion, 92% had a low risk, 3% had a moderate risk, and 3% had a high risk (van Vliet et al. 2005). Agricultural land in the Beaver River, Big Muddy Creek and Poplar River Watersheds have, on average, moderate risk for water erosion. All other Saskatchewan watersheds that were assessed have, on average, low risk for water erosion.

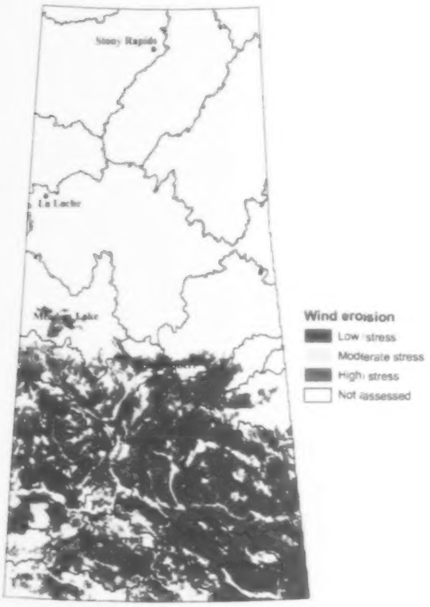


Figure 40. Wind erosion risk of annually cultivated soils at a Soil Landscape basis with the watershed boundary overlay.

Data Source: Rostad and Padbury 2005.

Of the land assessed for wind erosion, 88% had a low risk, 7% had a moderate risk, and 5% had a high risk (Rostad and Padbury 2005). Agricultural land in the assessed watersheds has, on average, low risk for wind erosion.

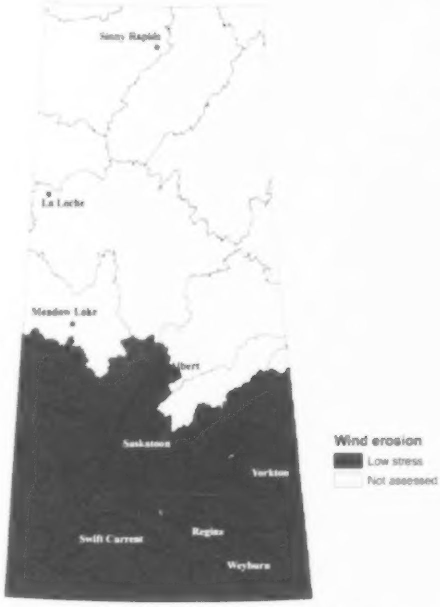


Figure 41. Wind erosion risk of annually cultivated soils by watershed: 2001.

Data Source: Rostad and Padbury 2005.

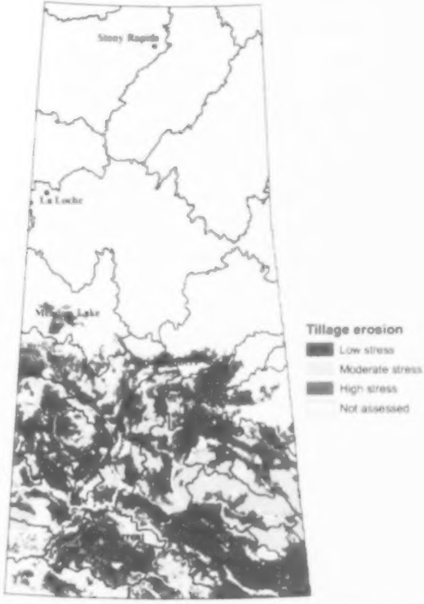


Figure 42. Tillage erosion risk of annually cultivated soils at a Soil Landscape basis with the watershed boundary overlay.

Data Source: Lobb 2005.

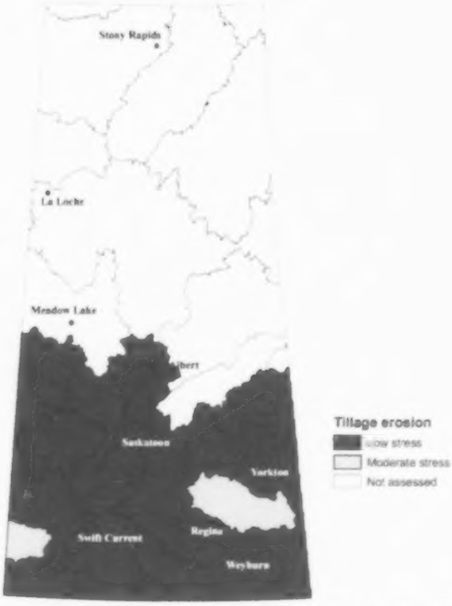


Figure 43. Tillage erosion risk of annually cultivated soils by watershed: 2001.

Data Source: Lobb 2005.

Of the land assessed for tillage erosion, 72% had a low risk, 27% had a moderate risk, and 1% had a high risk (Lobb 2005). Agricultural land in the Cypress Hills North Slope and Upper Qu'Appelle River Watersheds have, on average, moderate risk for tillage erosion. All other Saskatchewan watersheds that were assessed have, on average, low risk for tillage erosion.

Indicator

Three models can be used to calculate soil loss: the Revised Universal Soil Loss Equation - For Application in Canada (RUSLE-FAC), the Wind Erosion Equation (WEQ) and the Tillage Erosion Risk Indicator (TillERI) model.

The RUSLE-FAC is a soil erosion model that predicts long-term average potential soil loss risk caused by rainfall and runoff.

RUSLE-FAC: $A = R \times K \times L \times S \times C \times P$

where:

- **A** Estimated erosion in tons per acre per year
- ***R*** Rainfall erosivity factor (the amount and intensity of rainfall an area receives)
- ***K*** Soil erodibility factor (calculated using several physical soil properties: texture, organic matter, infiltration rate and structure)
- ***L*** Slope length factor
- ***S*** Slope steepness factor
- ***C*** Cover and management factor
- ***P*** Support practice factor [practices used for erosion control (contours, terraces, strip cropping)]

The WEQ is a model that predicts soil loss caused by wind.

WEQ: $E = f\,(I, K, C, L, V)$

where:

- **E** Estimated erosion in tons per acre per year
- **f** Function of ( )
- **I** Erodibility factor (e.g. texture and aggregation)
- **K** Surface roughness factor (e.g. ridges)
- **C** Climate factor
- **L** Unsheltered length of field factor (i.e. how open the field is)
- **V** Vegetative cover factor (i.e. cover type, density, etc.)

The TillERI is a model that predicts soil loss risk caused by tillage.

$$ATE = ET * EL$$

where:

- **ATE** = Rate of soil loss by tillage erosion ($t\ ha^{-1}\ yr^{-1}$)
- **ET** = Tillage erosivity ($t\ \%^{-1}\ m^{-1}\ yr^{-1}$)
- **EL** = Landscape erodibility ($\%\ m\ ha^{-1}$)

Soil erosion classes were developed for crop productivity purposes, not water quality concerns. The criteria for defining the tolerance limits for the purpose of preventing or reducing damage to offsite water quality may be distinct from those tolerances designed to preserve cropland productivity (Renard et al. 1997).

Figure 40. Wind erosion risk of annually cultivated soils at a Soil Landscape basis with the watershed boundary overlay.

Figure 41. Wind erosion risk of annually cultivated soils by watershed: 2001.

Figure 42. Tillage erosion risk of annually cultivated soils at a Soil Landscape basis with the watershed boundary overlay.

Figure 41. Tillage erosion risk of annually cultivated soils by watershed: 2001.

[illegible]

Indicator

[illegible]

RUSLE-FAC: $A = R \times K \times L \times S \times C \times P$

where:

A [illegible]

R [illegible]

K [illegible]

L [illegible]

S [illegible]

C [illegible]

P [illegible]

[illegible]

WEQ: $E = f\,(I, K, C, L, V)$

where:

E [illegible]

I [illegible]

K [illegible]

C [illegible]

L [illegible]

V [illegible]

[illegible]

ATI = [illegible] TT [illegible] TL

where:

ATI = [illegible]

TT = [illegible]

TL = [illegible]

[illegible]

Rating Scheme

The rating system from Wall et al. (2002) has been revised to conform to the categories used for the stressor indicators in this document.

Soil Erosion
Low stress: Soil erosion is less than 11 tonnes/hectare/year.
Moderate stress: Soil erosion is between 11 and 22 tonnes/hectare/year.
High stress: Soil erosion is greater than 22 tonnes/hectare/year.

Data Source: The water, wind and tillage erosion information used to calculate this indicator was obtained from the Soil Erosion Chapter of the *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series – Report #2* (Lefebvre et al. 2005). The land cover data are from the Southern Digital Land Cover classification of 1993-1994 LANDSAT-TM.

Data Handling: The calculation methods for water, wind and tillage erosion can be found in the Soil Erosion Chapter of the *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series – Report #2* (Lefebvre et al. 2005). Soil erosion estimates are at a 1:1,000,000 scale, utilizing Soil Landscape of Canada polygons. Soil erosion calculations are only for the annually cultivated area of a Soil Landscape of Canada polygon.

Average soil erosion by watershed was calculated using a weighted average where, the percent of the watershed in each of the three risk classes was multiplied by an erosion risk rate. The erosion risk rates used were: low risk areas = 5.5 tonnes/ha/yr; moderate risk areas = 16.5 tonnes/ha/yr; and high risk areas=22 tonnes/ha/yr.

Data Discussion: Temporal analysis can take place on a five-year basis as determined by the Agriculture Census.

Response to the issue

Sediment deposition caused by soil erosion can impact surface water quality and aquatic habitat. Surface water quality is protected under the Interim Surface Water Quality Objectives (Saskatchewan Environment 2006b). The Fisheries Act protects fish habitat from the deposition of deleterious substances, such as sediment.

Agricultural Beneficial Management Practices that can reduce soil erosion as promoted by the Environmental Farm Plan, in the Guide to the Canada-Saskatchewan Farm Stewardship Program (CSFSP) include:

- riparian area management;
- erosion control structures;
- land management for soils at risk;
- cover crops;
- improved cropping systems;
- shelterbelt establishment; and
- soil erosion control planning.

Other agricultural Beneficial Management Practices that have reduced the risk of soil erosion in Saskatchewan caused by water, wind and tillage include: the move away from conventional tillage to minimum and zero tillage practices; and the reduction in the practice of summerfallow.

Fertilizer Inputs Indicator

The issue

Fertilizers are commonly used to increase crop production and enhance home lawns. Fertilizers maintain and increase the nutrient availability of soils for plant growth. Runoff, leaching and infiltration of nutrients from fertilizers can impact both surface and groundwater sources. Elevated nitrate levels in drinking water can pose serious risks to infants. Nutrient loading from fertilizers can result in eutrophication of surface water, causing increased algal blooms and thereby decreasing overall water quality.

Fertilizer Inputs Indicator in Saskatchewan

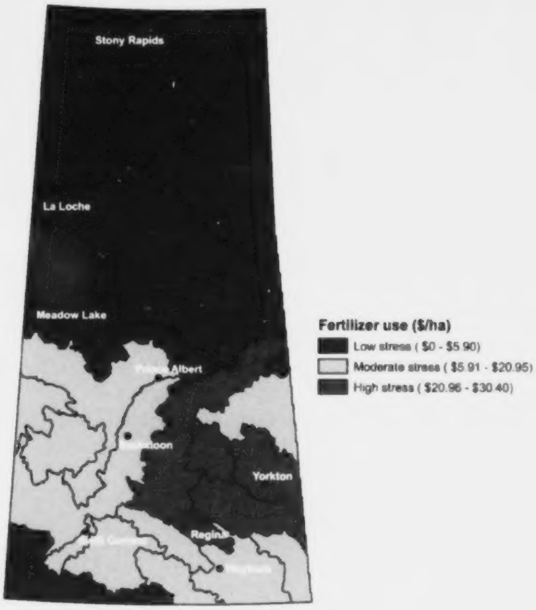


Figure 44. Fertilizer use by watershed: 2001.

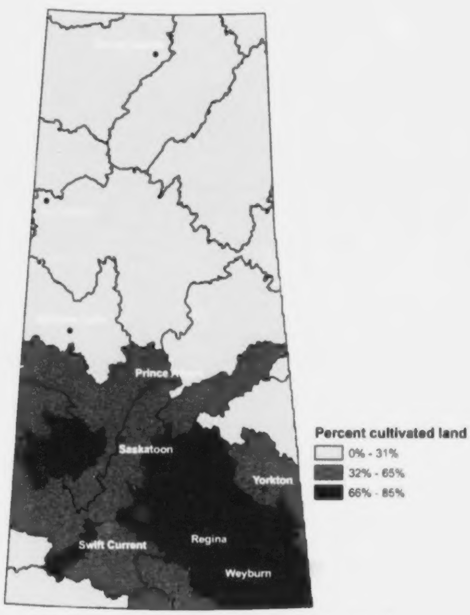


Figure 45. Percent cultivated area by watershed.

In 2001, relative to all watersheds in Saskatchewan, the fertilizer use in the Assiniboine River, Carrot River, Lower Qu'Appelle River, Upper Qu'Appelle River, Quill Lakes, and Wascana Creek Watersheds had the greatest stress potential. All of the watersheds with moderate and high stress potential had greater than 40% cultivated area, with the exception of the Lake Winnipegosis Watershed, which had 29% cultivated area. Watersheds with a small percentage of cultivated area and high fertilizer input costs have increased potential for risks of fertilizer contamination to local waterways and groundwater.

Indicator		
Fertilizer Input Intensity	=	$\frac{\text{Fertilizer input cost (\$)}}{\text{Total watershed area (ha)}}$

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so, the Jenks' optimization method was used to find the natural breaks in the data.

Fertilizer Input Intensity
Low stress: Fertilizer use is less than $5.91/hectare.
Moderate stress: Fertilizer use is between $5.91 and $20.95/hectare.
High stress: Fertilizer use is between than $20.96 and $30.40/hectare.

Data Source: Fertilizer data for this indicator were obtained from the Census of Agriculture for the 2001 census year (Statistics Canada 2002a). The cultivated area by watershed was obtained from the Southern Digital Land Cover classification.

Data Quality/Caveats: By dividing the fertilizer use in the watershed by the total watershed area instead of the cropped area within the watershed the measure assesses the health of the entire watershed, not just the health of the cropped areas.

Data Discussion: This measure permits temporal and spatial trends to be analyzed. However, it does not directly measure the potential impact fertilizers have on the health of watersheds. To further assess the potential impact of chemical application on watersheds an estimate of the mass of chemical loadings per watershed is needed. Using information on the amount of fertilizer added and the amount of fertilizer removed during cropping, it would be possible to estimate the potential amount of excess fertilizer that has been added. Using this information a leaching potential and the runoff potential of nitrogen and phosphorus could be determined.

In the *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series - Report #2* (Lefebvre et al. 2005), an indicator to assess the Risk of Water Contamination by Nitrogen (IROWC-N) was developed for all of Canada at a provincial scale (De Jong et al. 2005). IROWC-N looked at the risk of surface water bodies contaminated by nitrogen moving from agricultural areas treated with fertilizers and manure. It should be noted that IROWC-N has several limitations, as the calculation of this indicator has many assumptions and approximations and the results are estimates of the risk of water contamination by nitrogen. Despite these limitations, the IROWC-N does identify areas in Saskatchewan that are at risk for nitrogen movement to surface water bodies.

Response to the issue

Fertilizers used in Canada are regulated under the *Fertilizers Act* and *Regulations*, administered by the Canadian Food Inspection Agency. Some of the activities that the Canadian Food Inspection Agency is involved with include: registration of fertilizers; review of fertilizer product safety, efficacy, and labelling; monitoring for active ingredients and contaminants in the market place; administering the Canadian Fertilizer Quality Assurance Program (CFQAP); and inspection and enforcement.

Within the province of Saskatchewan, Saskatchewan Environment regulates *The Hazardous Substances and Waste Dangerous Goods Regulations* and *The Environmental Spill Control Regulations* under *The Environmental Management and Protection Act, 2002*.

To receive and record province-wide reports of spills and environmental emergencies, Saskatchewan Environment established the Provincial Enforcement Centre Spill Report Line. The Provincial Enforcement Centre staff can provide advice on reported spills and confirm if containment and cleanup measures are adequate.

The provincial and federal governments promote agricultural Beneficial Management Practices related to fertilizer application through the Canada-Saskatchewan Farm Stewardship Program. Agricultural Beneficial Management Practices related to fertilizer application include:

- product and waste management;
- improved cropping systems; and
- nutrient management planning.

To assist producers with fertilizer application Saskatchewan Agriculture and Food has developed several fact sheets, such as:

- Guidelines for Safe Rates of Fertilizer Placed with the Seed (2006);
- Nitrogen Fertilization in Crop Production (2005a);
- Phosphorus Fertilization in Crop Production (2005b);
- Sulphur Fertilization in Crop Production (2003b); and
- Fertilizer Management for Seed Production of Perennial Forages in Saskatchewan (2004b).

Pesticide Inputs Indicator

The issue

Agricultural application of pesticides has the potential to contaminate aquatic ecosystems as a result of processes such as leaching, surface runoff, and/or atmospheric deposition such as spray drift or wind erosion. Pesticides have been detected in lakes, wetlands and groundwater in Saskatchewan (Donald et al. 1999, Donald and Syrgiannis 1995).

Pesticides can have toxic effects on aquatic species by impacting them in many ways, such as altering reproduction, behaviour, physiological processes, biochemical function, and survival of young and other sensitive life stages.

Pesticide Inputs Indicator in Saskatchewan

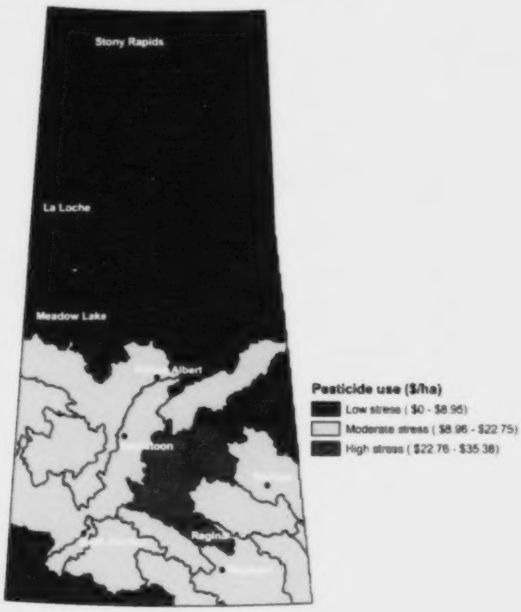


Figure 46. Pesticide use by watershed: 2001.

In 2001, the watersheds with the greatest pesticide use and relative stress potentials were the Quill Lakes, Upper Qu'Appelle River and Wascana Creek Watersheds. All of the watersheds with moderate and high stress potential had greater than 40% cropped area. Watersheds with a smaller percentage of cultivated area and high pesticide inputs for these cultivated areas have increased potential for risks of pesticides contaminating local waterways and groundwater.

Indicator		
Pesticide Input Intensity	=	Pesticide input cost ($) / Total watershed area (ha)

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so, the Jenks' optimization method was used to find the natural breaks in the data.

Pesticide Input Intensity
Low stress: Pesticide use is less than $8.96/hectare.
Moderate stress: Pesticide use is between $8.96 and $22.75/hectare.
High stress: Pesticide use is between $22.76 and $35.38/hectare.

Data Source: Pesticide use data for this indicator were obtained from the Census of Agriculture for the census year 2001 (Statistics Canada 2002a).

Data Quality/Caveats: By dividing the pesticide use in the watershed by the total watershed area instead of the cropped area within the watershed the measure assesses the health of the entire watershed, not just the health of the cropped areas.

In order to protect the privacy of individual farms, the Agriculture Census does not provide data in rural municipalities with less than two farms reporting. It is assumed that the missing data due to this privacy policy are negligible.

Data Discussion: This measure permits temporal and spatial trends to be analyzed. However, it does not directly measure the potential impact fertilizers and pesticides have on the health of watersheds. To further assess the potential impact of chemical application on watersheds, an estimate of the mass of chemical loadings per watershed is needed. Using the current data it is not possible to calculate chemical loading to waterways.

Response to the issue

All pesticides imported into, sold, or used in Canada are regulated under the *Pest Control Products Act* and *Regulations*, administered by the Pest Management Regulatory Agency (PMRA) of Health Canada. Some of the activities the PMRA is involved with include registering pest control products, re-evaluating registered products, and setting maximum residue limits under the *Food and Drugs Act* (Health Canada 2003).

Within the province of Saskatchewan, Saskatchewan Agriculture and Food regulates, under *The Pest Control Products (Saskatchewan) Act* and *Regulations, 1995*, the sale, use, storage, transportation and disposal of registered pesticides. *The Hazardous Substances and Waste Dangerous Goods Regulations* and *The Environmental Spill Control Regulations* under *The Environmental Management and Protection Act, 2002*, are administered by Saskatchewan Environment.

In addition to legislation, Saskatchewan Industry and Resources administers a number of guidelines related to spills, contaminated sites and waste disposal from upstream oil and gas operations. These include: the Spill Site Reclamation Guidelines; the Upstream Contaminated Sites Remediation and Environmental Site Assessment Guidelines; the Drilling Waste Management and Frac Fluid and Sand Disposal Guidelines; and the Interim Draft Industrial Landfilling Requirements for Wastes Generated from Upstream Oil and Gas Industry.

Saskatchewan Environment established the Provincial Enforcement Centre Spill Report Line to receive and record province-wide reports of spills and environmental emergencies. The Provincial Enforcement Centre staff can provide advice on reported spills and confirm if containment and cleanup measures are adequate.

The Government of Saskatchewan promotes licensing and education, such as:

- The Pesticide Applicator License, which is mandatory for all individuals and employees who conduct custom pesticide application. Prior to obtaining a license, applicants must complete and pass the Pesticide Training Course offered through the Saskatchewan Institute of Applied Science and Technology (SIAST).
- The Government of Saskatchewan does not require individuals who purchase and apply pesticides for their personal use to obtain a pesticide application certificate. However, individuals applying pesticides on their own property can obtain a voluntary Private Pesticide Applicator Certificate (Saskatchewan Agriculture and Food, Unpubl.).
- Saskatchewan Agriculture and Food releases The Guide to Crop Protection in May of each year. This annually-updated document contains corrections and new uses that have been registered since the previous printing. The Guide to Crop Protection provides information on the use of pesticides for the control of undesirable weeds, plant diseases and insects.
- Pesticide labels provide users with information that, if followed, reduces the risk of pesticide contamination to surface and groundwater. All registered pesticides must have a label attached to the pesticide container. The label includes the name of the pesticide, its toxicity and hazard rating, the concentration of the active ingredient, the directions for use, including the application rate, and information on first aid treatment.

In addition to legislation and education, the federal and provincial governments both promote Beneficial Management Practices in Saskatchewan through the Canada-Saskatchewan Farm Stewardship Program. Beneficial Management Practices related to pesticide application include:

- product and waste management;
- improved pest management; and
- integrated pest management planning.

The Government of Saskatchewan's Noxious Weed Management Program encourages integrated weed control through a combined approach of physical, chemical, biological and ecological methods.

Research is also being done on integrated pest management in the province, including:

- Staff at Agriculture and Agri-Food Canada's Saskatoon Research Centre are conducting research on weed biocontrol. The goal of the program is to reduce the producer's dependency on chemical herbicides through the development of microbial weed biocontrol agents for use in agricultural systems.
- Staff at Agriculture and Agri-Food Canada's Saskatoon Research Centre are also involved in research on ecological pest management. The research is focused on four components of ecological pest management:
  - biological control of weeds;
  - biological control of insect pests;
  - resistance to insects in canola; and
  - integrated management tactics.

Manure Application Indicator

The issue

Manure is typically applied to land at the level of nitrogen required, which may result in other nutrients, including phosphorus, being applied in excess of crop requirements. Therefore, if manure is applied at an appropriate rate for nitrogen the application will increase the potential for ground and surface water contamination by phosphorus. Nutrient loading from manure can have the same impact as nutrient loading from fertilizers, and can result in eutrophication of surface water, causing increased algal blooms and decreased water quality.

Manure Application Indicator in Saskatchewan

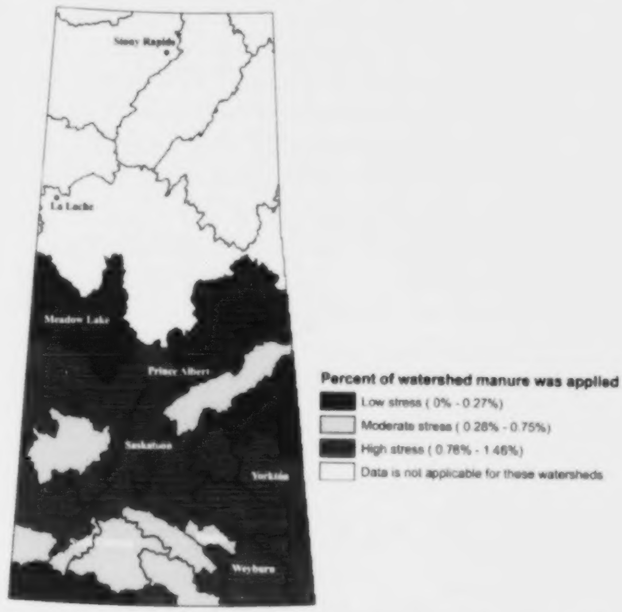


Figure 47. Percentage of watershed where manure was applied: 2001.

In 2001, livestock manure was applied to a small proportion of any given watershed, with less than 2% of any watershed receiving manure. This indicator evaluates those watersheds where the most manure is produced as being at the greatest relative risk. Although 2% of the total watershed is a small value, manure is often produced in concentrated areas, and is therefore not evenly applied throughout the watershed. This can present a localized risk potential within the greater watershed area.

Indicator

Percentage of Watershed where Manure was Applied $= \dfrac{\text{Area of manure application in watershed (ha)}}{\text{Total watershed area (ha)}} \times 100$

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so, the Jenks' optimization method was used to find the natural breaks in the data.

Manure Application
Low stress: Manure is applied to less than 0.28% of the watershed.
Moderate stress: Manure is applied to between 0.28% and 0.75% of the watershed.
High stress: Manure is applied to more than 0.75% of the watershed.

Data Source: Manure application data were obtained from the 2001 Census of Agriculture (Statistics Canada 2002a).

Data Quality/Caveats: This indicator does not take into account the type of animal manure or the method, timing, or location of manure application. All of these factors have the potential to influence the risk of surface water and groundwater contamination.

Data Discussion: Censuses of other years (every five years) can be used for illustrating temporal trends.

To further assess the potential impact of manure application on watersheds, an estimate of the potential risk of nitrogen loading to surface water bodies should also be considered. Please see the IROWC-N section of the Chemical Inputs Indicator for further information on nitrogen loading.

Response to the issue

Nutrient management planning of manure application is an important agricultural Beneficial Management Practice that can be used by livestock producers to reduce nutrient loading from manure to surface and groundwater. There are two ways that producers can reduce the potential of nutrient contamination to water sources. These include: 1) applying manure at an application rate that will meet the nutrient requirements of the crop; and 2) reducing excess phosphorus in the manure.

Other Beneficial Management Practices that are promoted through the Canada-Saskatchewan Farm Stewardship Program and have the potential to reduce the environmental risk of manure application in Saskatchewan include:

- improved manure storage and handling;
- manure treatment; and
- manure land application.

Saskatchewan Agriculture and Food actively promotes extension events related to manure management (see the **Stewardship Workshops Indicator**).

Saskatchewan Agriculture and Food also have many documents related to manure management on their website, at: http://www.agr.gov.sk.ca/Livestock/pork.asp?firstPick=Livestock&secondpick=Pork&thirdpick=Manure%20Management&selection=Manure%20Management.

Oil & Gas

The extraction, refinement, and transportation of oil and gas within Saskatchewan are important components of our economy, contributing approximately $2 billion in 2003 (CAPP 2003). All three sectors are environmentally regulated by the *Provincial Oil and Gas Regulations* to ensure proper reclamation of environments impacted by the oil and gas industry.

Oil and gas exploration and development has the potential to impact watershed health in a number of ways, including: oil spills; wastewater disposal; leaching of surface discharge; stormwater runoff from well sites; surface water and groundwater extraction activities; leaking of transport pipelines and underground storage; and impairment of freshwater aquatic life caused by the aforementioned activities (Confluence Consulting Inc. 2004).

Provincially, the oil and gas regulations ensure that operations incorporate multiple built-in containment and protection systems to ensure there is little or no impact to the air, land and water. It is important to have indicators that measure the potential risk of these activities.

Oil and Gas Spills Indicator

The issue

Although less than 1% of the total water consumed in Saskatchewan is used by upstream petroleum operations, which includes all activities that find, produce, and process oil and natural gas (Saskatchewan Environment 2003), there still remains the potential for groundwater contamination. Incidents such as gas migration and casing leaks pose contamination threats to groundwater, a threat that increases with the number of wells drilled per unit area. Upstream oil and gas spills are spills of unrefined products, such as crude oil, natural gas and condensates.

Oil and Gas Spills Indicator in Saskatchewan

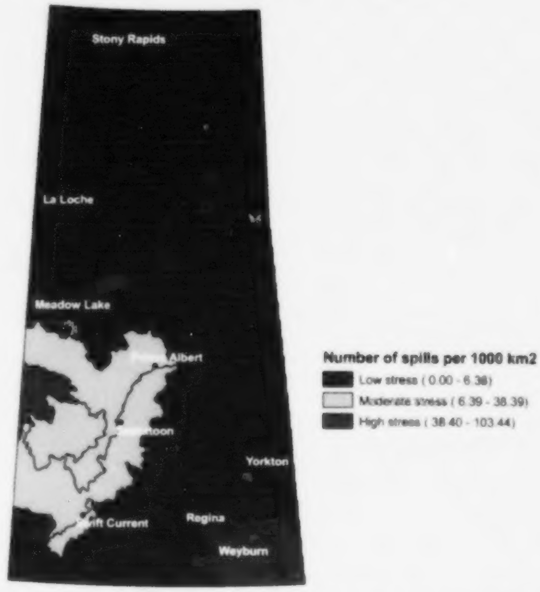


Figure 48. Number of reported oil and gas spills per square kilometre between 1993 and 2003, by watershed.

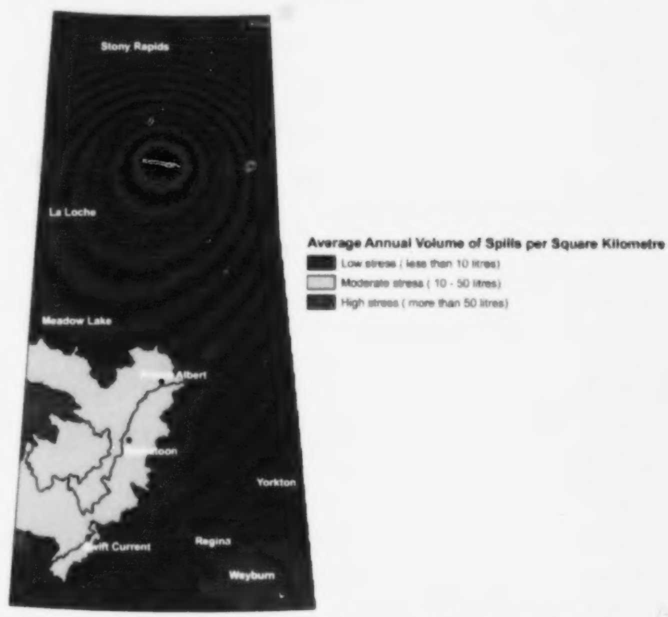


Figure 49. Average annual volume of reported oil and emulsion spills per square kilometre between 1993 and 2003, by watershed.

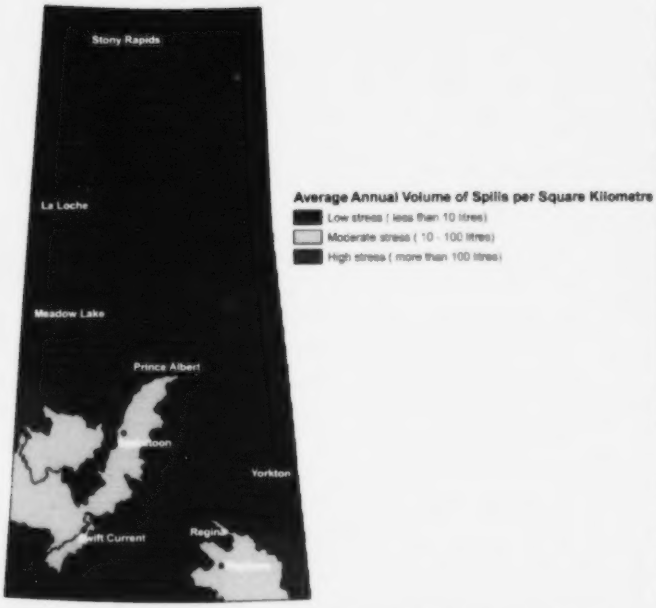


Figure 50. Average annual volume of reported saltwater spills per square kilometre between 1993 and 2003, by watershed.

The number of reported oil and gas spills and the average annual volume of oil and gas spills per square kilometre are categorized as being of high stress potential in the Lower and Upper Souris River and Battle River Watersheds. The North Saskatchewan River, South Saskatchewan River, Eagle Creek, and Swift Current Creek Watersheds are categorized as having moderate stress potential. All other watersheds have a low stress potential. The total number of oil and gas wells in Saskatchewan will continue to increase in the foreseeable future. This rate of increase can be determined by observing the number of wells drilled each year. Since the number and volume of oil and gas spills by watershed is highly correlated with the number of oil and gas wells within the watershed ($r2=0.73$, $p<0.001$), as the number of oil and gas wells increases we can predict an increase in the number and volume of oil and gas spills.

Indicator	
Number of Oil and Gas Spills per Square Kilometre	= $\frac{\text{Number of oil and gas spills between 1993 and 2003}}{\text{Total watershed area (km}^2\text{)}}$
Average Annual Volume of Oil and Emulsion Spills per Square Kilometre	= $\frac{\text{Average annual volume of oil and emulsion spills (litres)}}{\text{Total watershed area (km}^2\text{)}}$
Average Annual Volume of Saltwater Spills per Square Kilometre	= $\frac{\text{Average annual volume of saltwater spills (litres)}}{\text{Total watershed area (km}^2\text{)}}$

Note: Upstream oil and gas spills are spills of unrefined products, such as crude oil, natural gas and condensates.

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to find the natural breaks in the data.

Number of Oil and Gas Spills per Square Kilometre
Low stress: The number of oil and gas spills is less than 6.39 spills/1,000 km².
Moderate stress: The number of oil and gas spills is between 6.39 and 38.39 spills/1,000 km².
High stress: The number of oil and gas spills is greater than 38.39 spills/1,000 km².
Average Annual Volume of Oil and Emulsion Spills per Square Kilometre
Low stress: The average annual volume of oil and emulsion spills is less than 10 litres/km².
Moderate stress: The average annual volume of oil and emulsion spills is between 10 and 50 litres/km².
High stress: The average annual volume of oil and emulsion spills is greater than 50 litres/km².
Average Annual Volume of Saltwater Spills per Square Kilometre
Low stress: The average annual volume of saltwater spills is less than 10 litres/km².
Moderate stress: The average annual volume of saltwater spills is between 10 and 100 litres/km².
High stress: The average annual volume of saltwater spills is greater than 100 litres/km².

Data Source: The number and volume of oil and gas spills in Saskatchewan was obtained from Saskatchewan Industry and Resources' Upstream Oil and Gas Sites Spill Database.

Data Handling: Saskatchewan Industry and Resources' database contains information on oil and gas spills between 1991 and 2005. However, spill data for 2004 and 2005 are currently incomplete.

Data Quality/Caveats: Upstream oil and gas spills are spills of unrefined products, such as crude oil, natural gas and condensates. The Oil and Gas Spill Indicator estimates the relative stress potential of an upstream oil and gas spill. Figures 49 and 50 are based on the volume of spills and they do not take into account the amount of materials recovered from the spill. On average, 71% of oil and emulsion spills and 54% of saltwater spills are recovered.

Response to the issue

The oil and gas industry is regulated in Saskatchewan by *The Mineral Resources Act, 1985, The Oil and Gas Conservation Act, The Oil and Gas Conservation Regulations, 1985*, and *The Seismic Exploration Regulations, 1999*, administered by Saskatchewan Industry and Resources, and *The Hazardous Substances and Waste Dangerous Goods Regulations* and *The Environmental Spill Control Regulations* under *The Environmental Management and Protection Act, 2002*, administered by Saskatchewan Environment.

In addition to legislation, Saskatchewan Industry and Resources administers a number of guidelines related to spills, contaminated sites and waste disposal from upstream oil and gas operations. These include: the Spill Site Reclamation Guidelines; the Upstream Contaminated Sites Remediation and Environmental Site Assessment Guidelines; the Drilling Waste Management and Frac Fluid and Sand Disposal Guidelines; and the Interim Draft Industrial Landfilling Requirements for Wastes Generated from Upstream Oil and Gas Industry.

Saskatchewan Environment established the Provincial Enforcement Centre Spill Report Line to receive and record province-wide reports of spills and environmental emergencies. The Provincial Enforcement Centre staff can provide advice on reported spills and confirm if containment and cleanup measures are adequate.

Mines Indicator

The issue

Mines can affect watershed health through the release of air- and water-borne chemicals, by increasing water temperature, and by altering flow characteristics of rivers. Some abandoned mine sites pose significant physical and/or environmental hazards. One of the environmental hazards of abandoned mines is contamination of surface and groundwater from acid mine drainage of tailings or deposits. Acid mine drainage is caused by the metabolic activity of the bacteria *Thiobacillus ferrooxidans*, which oxidizes iron and inorganic sulfur compounds found in mine tailings and coal deposits.

Mine Indicator in Saskatchewan

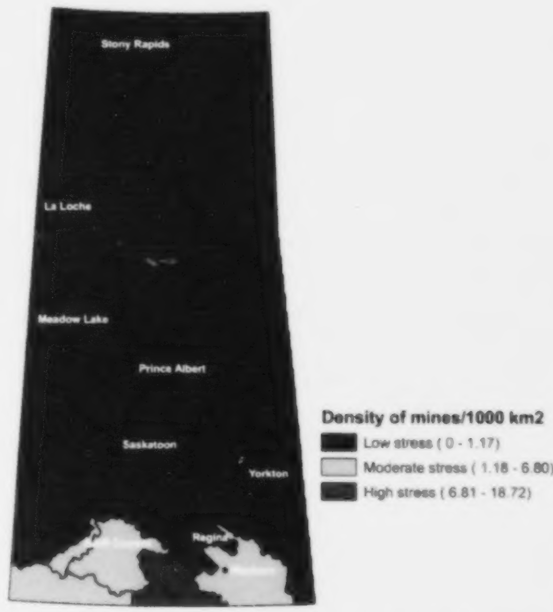


Figure 51. Density of active, inactive and abandoned mines per 1,000 square kilometres.

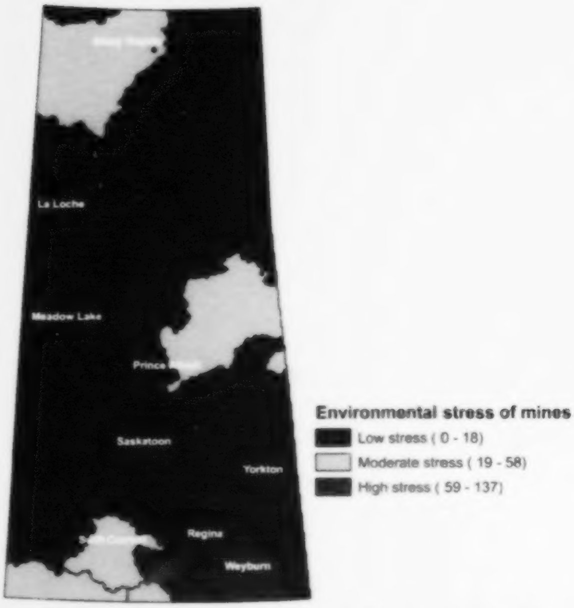


Figure 52. Potential environmental risk of active, inactive and abandoned mines.

The majority of mines are in the southern part of the province. However, the potential environmental risk is greater for some of the northern uranium mines.

Indicator		
Density of Mines =	Number of active, inactive and abandoned mines per watershed / Total watershed area (1000 km²)	
Environmental stress of mines	= ∑ [(Number of active, inactive and abandoned mines)	× (Environmental risk class)]

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so, the Jenks' optimization method was used to find the natural breaks in the data.

Density of Mines per km²
Low stress: The density of mines is less than 1.18/1,000 km².
Moderate stress: The density of mines is between 1.18 to 6.80/1,000 km².
High stress: The density of mines is greater than 6.80/1,000 km².
Environmental Stress of Mines by Watershed
Low stress: Environmental stress of mines by watershed is less than 19.
Moderate stress: Environmental stress of mines by watershed is between 19 and 58.
High stress: Environmental stress of mines by watershed is greater than 58.

Data Source: The location and type of active and inactive mines was obtained from the Geological Atlas of Saskatchewan (Saskatchewan Industry and Resources 2004). Information on the abandoned mines was obtained from four reference documents [Saskatchewan Environment and Public Safety 1989, (KHS) Environmental Management Group Ltd. 2001, Clifton Associates Ltd. 2002, and Clifton Associates Ltd. 2003].

Data Handling: The environmental stress classes were calculated using a number of criteria. The environmental stress classes were based on the type of mines, where: copper/zinc, gold and uranium mines were considered higher risk = 3; potash, potash/salt, potassium sulphate, salt and sodium sulphate mines were considered moderate risk = 2; and bentonite, clay, coal, silica sand, stone and peat mines were considered lower risk = 1. For the abandoned mines in northern Saskatchewan where an environmental stress had previously been determined and documented [(KHS) Environmental Management Group Ltd. 2001, Clifton Associates Ltd. 2002, and Clifton Associates Ltd. 2003], the environmental stress classes were based on these ratings.

Response to the issue

Mining operations are regulated in Saskatchewan by: *The Mineral Resources Act, 1985* and *The Seismic Exploration Regulations, 1999*, administered by Saskatchewan Industry and Resources; *The Mineral Industry Environmental Protection Regulations, 1996*, administered by Saskatchewan Environment; and the *Metal Mining Effluent Regulations* and Guidelines, administered under the *Fisheries Act*.

To promote best management practices for mineral exploration, the Saskatchewan Mineral Exploration and Government Advisory Committee (SMEGAC) developed the *Mineral Exploration Guidelines for Saskatchewan* (Saskatchewan Mineral Exploration and Government Advisory Committee 2005). These guidelines provide information on best management practices to assist proponents in reducing the environmental impacts of planning, initiating and completing a mineral exploration program.

To assess the impacts of mining operations on water quality a number of water quality monitoring programs were initiated:

- The National Environmental Effects Monitoring Program is a requirement for all metal mines under the *Metal Mining Effluent Regulations*, under the *Fisheries Act*. The Environmental Effects Monitoring program consists of a number of monitoring surveys, including:
  - *the Fish Survey* (biological monitoring survey);
  - *the Benthic Invertebrate Community Survey* (biological monitoring survey);
  - *Fish Usability* (biological monitoring survey);
  - *Alternative Monitoring Methods;*
  - *Sublethal Toxicity Testing*; and
  - *Environmental Supporting Variables.*
- Saskatchewan Environment's Cumulative Effects Monitoring Program has been collecting samples in northern Saskatchewan since 1994. The program collects water, sediment, aquatic macrophyte, and fish tissue samples from class effects and regional effects sampling stations once a year on a three-year rotation.
- The Athabasca Working Group's Environmental Monitoring Program was initiated in 2000 as a joint community-based environmental monitoring program between three uranium mining companies (Cameco Corporation, COGEMA Resources and Cigar Lake Mining Corporation) and seven Athabascan communities (Wollaston Lake, Hatchet Lake, Black Lake, Stony Rapids, Fond-du-Lac, Uranium City, and Camsell Portage). The program collects and analyses water, lake sediment, and plant and animal samples to assess the environmental impact related to uranium mining.

In the late 1980's Saskatchewan Environment (previously Saskatchewan Environment and Public Safety) established the Abandoned Mines Remedial Action Program to identify all of the abandoned mining operations in Saskatchewan. Due to budget constraints the project was terminated in the early 1990's. In 2000, through funding from the Province of Saskatchewan's Centenary Fund, Saskatchewan Environment and Resource Management (SERM) initiated the Abandoned Mines Assessment Program. The purpose of this program was to assess the identified abandoned mine sites in northern Saskatchewan and prioritize these sites based on risk to public safety and environmental concerns. Through this program, consulting companies assessed 75 mine sites in northern Saskatchewan between 2000 and 2002. In year two and three of this program the acid mine drainage potential was also recorded. The information collected during this program has been compiled into three documents written by consultants: (KHS) Environmental Management Group Ltd. (2001), Clifton Associates Ltd. (2002), and Clifton Associates Ltd. (2003).

Forestry Disturbance Indicator

The issue

Disturbance of forested areas caused by forestry activities, such as harvesting and road construction, can impact both aquatic and terrestrial ecosystems. Forestry activities can impact ecosystems by: increasing soil erosion; increasing nutrient and ion loading; transporting chemicals used in harvesting activities; increasing organic debris; changing temperature; fragmenting habitat; introducing invasive species; and increasing or decreasing streamflow. An investigation conducted by Pomeroy et al. (1997) on the hydrological processes in the southern boreal forest found that snowmelt occurs up to three times faster in clear-cut areas compared to mature stands. The faster snowmelt and increased runoff from these clear-cut areas resulted in less infiltration to groundwater and increased peak runoff.

Forestry Disturbance Indicator in Saskatchewan

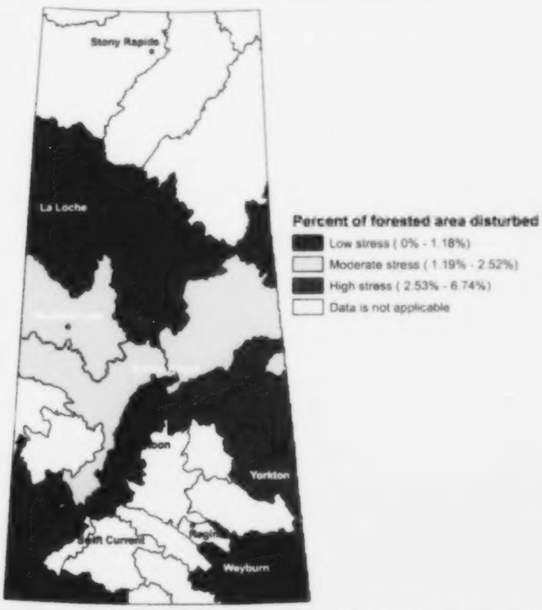


Figure 53. Percent of forested area disturbed in the last twenty years.

Thirteen of the twenty-nine watersheds in Saskatchewan have been, or are currently, commercially forested. The watersheds in the high stress category (the Assiniboine River, Carrot River, and Lake Winnipegosis Watersheds) all have more than five percent of the forested area harvested. Only 2% of the Assiniboine River Watershed is forested.

Indicator

$$\text{Percent of Forested Area Disturbed in Last 20 Years} = \frac{\text{Human disturbed forested area (ha)}}{\text{Forested area within the watershed (ha)}} \times 100$$

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to identify the natural breaks in the data.

Percent of Forested Area Disturbed in the Last 20 Years
Low stress: Percent of forested area disturbed is less than 1.19%.
Moderate stress: Percent of forested area disturbed ranges from 1.19% to 2.52%.
High stress: Percent of forested area disturbed is greater than 2.52%.

Data Source: The disturbance type and year were obtained from Saskatchewan Environment Forestry Branch's Forest Inventory Data.

Data Handling: Forest inventory polygon tables were queried to extract any polygon that had a value entered for SA (species association) and/or DIST (disturbance type). This identified any areas that are currently forested or have been in the past.

Data Discussion: The intention of this indicator is to include and map all of the human disturbed forested areas by watershed. Currently, only the harvested (cutover) areas are included in Figure 53. Through the cooperation and collaboration of various organizations additional types of human disturbance data are being obtained.

Response to the issue

The Forest Resources Management Act and *Regulations*, administered by Saskatchewan Environment, promotes the sustainable management of forested lands through, in part, the protection of biodiversity and watersheds.

Saskatchewan Environment is also developing four legislated manuals that will assist in forestry management in Saskatchewan. These manuals include:

- the Forest Planning Manual;
- the Forest Operations Manual;
- the Compliance Manual; and
- the Scaling Manual.

In addition to legislation, Saskatchewan Environment is involved in integrated forest land use planning. The purpose of the integrated forest land use planning process is to identify and integrate existing land use interests (including environmental, economic, social, and cultural uses), resolve conflict, and develop land and resource management plans for Crown lands in the planning area. At present, Saskatchewan Environment has completed six Integrated Forest Land Use Plans in the province. These include:

- the Amisk-Atik Integrated Forest Land Use Plan;
- the Fort a la Corne Integrated Forest Land Use Plan;
- the Nisbet Integrated Forest Land Use Plan;
- the North-Central Integrated Forest Land Use Plan;
- the Pasquia Integrated Forest Land Use Plan; and
- the Pinehouse Integrated Forest Land Use Plan.

To reduce the effects of clear cutting and improve the likelihood of regeneration, forestry companies in Saskatchewan are now implementing harvest practices that have been designed to model natural fire patterns. Saskatchewan Environment began enforcing these new harvest practices beginning in 2004 (Saskatchewan Environment 2003). Recently burned areas tend to have less of an impact with regard to increased nutrient yields and mercury translocation than logged areas (Richter and Ralston 1982; Garcia and Carignan 1999). These new methods of harvesting could help reduce the effects of clear cutting and improve the likelihood of regeneration.

The Prince Albert Model Forest was formed in 1992 through partnerships with First Nations, federal and provincial resource management agencies. The Model Forest is 367,000 hectares in size and is located in the Mixedwood Section of the Southern Boreal Forest. The Model Forest is funded by the Canadian Forest Service under Canada's Green Plan. The Model Forest allows for integrated resource management planning and research.

Landfills Indicator

The issue

The principal environmental concern regarding the use of landfills for waste disposal is the production and containment of leachate. Leachate is water that percolates through the landfill waste and, if not properly contained, can enter surface or groundwater through infiltration and runoff. Leachate typically contains organic and inorganic compounds, some of which may be toxic depending on the type of waste deposited into the landfill.

Presently, Saskatchewan Environment estimates that there are 829 landfill sites in Saskatchewan. Information herein is based on a preliminary assessment of these landfills performed by Saskatchewan Environment. This information is limited in that it was gained through site visits and/or interviewing municipal staff in 2005 and 2006 (Saskatchewan Environment 2006d, 2006e, 2006f). The purpose of Saskatchewan Environment's assessment was to prioritize municipal landfills in terms of potential need for further investigation and resolution by the department. In conducting the assessment there was no intrusive investigation of on-site soil texture or hydraulic conductivity, distance to groundwater or distance to surface water. In establishing compliance priority classifications for further evaluation and resolution a number of other factors were examined which influenced the assessment ranking that have no direct bearing on stress to ground or surface water including proximity to inhalation receptors, population served by the landfill, and history of use.

Landfills Indicator in Saskatchewan

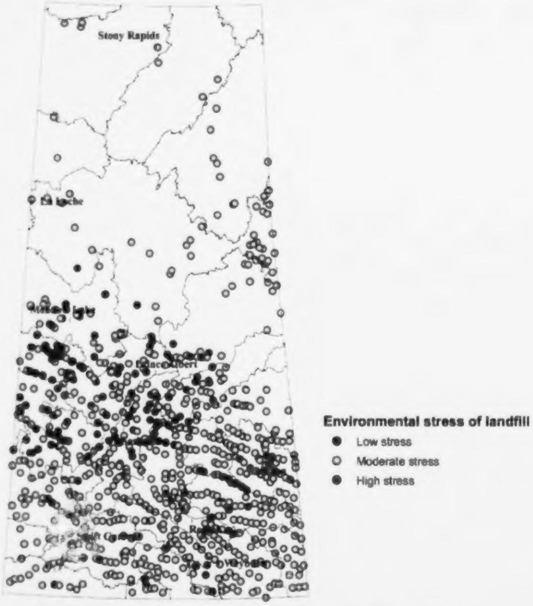


Figure 54. Potential environmental stress of landfills in Saskatchewan.

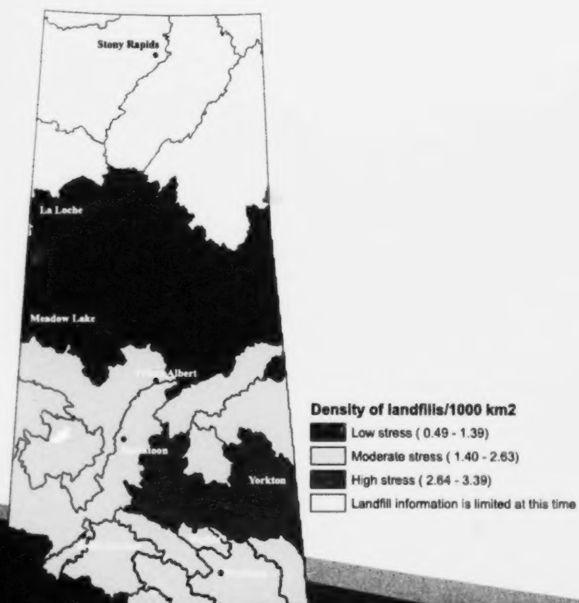


Figure 55. Density of landfills by watershed.

Of the 829 known landfills, 720 are municipal landfills. The status of the municipal landfills is as follows: 412 are currently operating, 305 are closed, and 3 landfill sites have an unknown status. Of the closed landfills, 98 of these have been turned into transfer stations. Transfer stations are collection sites used to transfer solid waste to regional landfills. Based on the department's compliance priority classification and the indicator method used, 59 landfills are considered high priority, 669 moderate priority, and 101 low priority.

Relative to all watersheds in Saskatchewan, the density of landfills is greatest for the Assiniboine River and the Upper and Lower Qu'Appelle River Watersheds.

Saskatchewan Environment is aware of and/or regulates around 120 sites in northern Saskatchewan and is developing a strategy to assess and achieve compliance with these landfill sites. Currently, limited information is available on these landfills in the northern watersheds to be able to discuss the compliance priority classification or density of landfills in these watersheds.

Indicator		
Environmental Stress of Landfill	=	Compliance Priority Classification for each landfill
Landfill Density by Watershed	=	$\frac{\text{Number of landfills}}{\text{Total watershed area (1,000 km}^2\text{)}}$

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to identify the natural breaks in the data.

Environmental Stress of Landfill
Low stress: Landfill is classified as a Class C compliance priority.
Moderate stress: Landfill is classified as a Class B compliance priority or the risk class of the landfill is unknown.
High stress: Landfill is classified as a Class A compliance priority (Saskatchewan Environment 1998).
Density of Landfills by Watershed
Low stress: Landfill density is less than 1.40/1,000 km².
Moderate stress: Landfill density ranges from 1.40 to 2.63/ 1,000 km².
High stress: Landfill density is greater than 2.63/1,000 km².

Data Source: Data for this indicator were obtained from the Waste Management and Contaminated Sites Unit of Saskatchewan Environment.

Data Handling: The environmental stress classes were weighted using the results of Saskatchewan Environment's landfill site suitability review questionnaire, which is to be used to assign a compliance priority classification system where: Class A (high compliance priority) = 3; Class B (moderate compliance priority) = 2; and Class C (low compliance priority) = 1. If the class of the landfill is unknown the compliance priority = 2, since there could be potential for infiltration and leachate migration. The landfill compliance priority classes were determined based on a questionnaire with the following criteria:

- number of people served by the waste disposal site and years in service;
- proximity of the site to residences, highways, surface water, groundwater wells and other receptors;
- operational practices at the site and whether it is supervised or not;
- potential for surface or groundwater contamination/migration off site;
- hydraulic connection with surrounding aquifers, if known; and
- acceptance of hazardous waste.

(Saskatchewan Environment 2004-2006 Site Suitability Review)

Data Quality/Caveats: The landfill classification used for this analysis was based on a recent questionnaire/survey completed by the landfill operators (if the site had one) and Saskatchewan Environment's environmental officers. The data are based on preliminary assessments completed by the department. For the majority of the landfill sites the information collected did not include any site-specific hydrogeologic information because this information was not available.

Data Discussion: Assessments of landfill locations and compliance priority classification is ongoing throughout the province.

Response to the issue

Saskatchewan Environment regulates landfills in Saskatchewan through *The Environmental Management and Protection Act, 2002*. This Act regulates and controls the disposal of deleterious substances and activities that are harmful to air, land and water resources. Other legislation involved in municipal landfill management includes *The Municipal Refuse Management Regulations (MRMR)*, *The Litter Control Act and Regulations*, *The Clean Air Act*, and *The Hazardous Substances and Waste Dangerous Goods Regulations*.

The Municipal Refuse Management Regulations were created in 1986 specifically for the management of the municipal landfill program, which the department inherited from the Department of Health in 1984. These regulations, in conjunction with *The Environmental Management and Protection Act, 2002*, regulate and permit municipal landfills in Saskatchewan. More specifically, Section 5 of *The Municipal Refuse Management Regulations* authorizes the establishment, operation or maintenance of a municipal waste disposal ground in accordance with sanitary or modified landfill practices. Further, Section 13 of *The Municipal Refuse Management Regulations* states that Ministerial approval is required for closing a municipal waste disposal ground.

Saskatchewan Environment inspects municipal landfills on a regular basis through its Landfill Delivery Program and strives for compliance and continual improvement of landfill management. The goals of this program are: to improve and develop efficient and effective landfill management; reduce the volume and toxicity of waste entering municipal landfills; deliver education, communication and enforcement vehicles that will ensure public safety, ecosystem health and public support for the program; and implement inspection and permitting programs for landfill operations. These goals are achieved through the department's regulatory and policy framework (legislation, policy, and compliance/enforcement); encouragement of the development of efficient and practical waste minimization, recycling/stewardship and regional waste systems; and effective communication with and education of the public. Through communication, education, and legislative and policy instruments, Saskatchewan Environment assists communities in managing resources available for the construction, operation and decommissioning of landfills. In 2005-06, the department re-instituted a continual improvement system for landfill management, beginning with a permitting strategy for municipal landfills (Saskatchewan Environment 2006g).

Key milestones have been achieved over the past number of years to improve solid waste management in Saskatchewan. These successes include a reduction in the number of landfills operating in the province through the establishment of several regional waste management systems and a reduction in or elimination of garbage being burned at the majority of landfills sites. In addition to this, the department has seen a reduction in the amount of waste going to Saskatchewan landfill sites through the establishment of its province-wide waste stewardship programs for used oil, scrap tires, beverage containers, waste paint, and pesticide containers. A waste electronic equipment program will soon be established for personal computers and televisions.

While significant progress has been made in improving solid waste management, there are still several issues/areas where Saskatchewan Environment acknowledges that improvements are required, including:

- The proper management of municipal refuse. Many municipalities are failing to comply with applicable legislation and regulations, and the department is being called upon by the public to increase its compliance and enforcement activities.
- Low commodity prices for recyclable materials is affecting the development and stability of regional recycling programs. In 2005-06 this resulted in the Province providing another $700,000 in short-term funding to regional waste management authorities while a long-term sustainable solution is developed.
- The public and some stakeholders continue to call for expanded recycling opportunities, especially for paper, plastic, tin and glass.

In order to address these and other issues, the department is developing a comprehensive Solid Waste Management Strategy (SWMS). Development and implementation of a SWMS and the supporting programs for recycling and landfill management are integral to achieving a green and prosperous economy and for moving the province towards achieving the Green Strategy strategic outcome of *"Sustainable Waste Management: the wise use of resources by producing less waste, using waste as a resource, increase recycling and ensuring effective waste management"* (Saskatchewan Environment 2005a).

The development of the SWMS with public and stakeholder support will create a long-term, comprehensive and affordable approach to resolving the current range of solid waste management issues. Initial consultations were held on a SWMS and now development work by Saskatchewan Environment is taking place (Saskatchewan Environment 2005b). The SWMS will incorporate feedback from stakeholders and the public on the overall development and implementation of the strategy. Improving solid waste management in the province will provide the opportunity to reduce risk to human health through improved landfill management while developing policies and programs that support residual waste management and waste minimization efforts.

Over the past 20 years, Saskatchewan Environment has made significant progress in dealing with solid waste management issues, including the development of regulations and legislation dealing with proper municipal waste management and the establishment of a number of stewardship programs. The following is a brief description of the department's accomplishments that have led to improved waste management (Saskatchewan Environment 2006h):

- The Beverage Container Collection and Recycling Program is authorized under *The Litter Control Act* and *Regulations* and is dedicated to providing a province-wide system to collect and recycle designated non-refillable beverage containers that have been distributed in Saskatchewan. The program is operated by SARCAN and in the 2004-2005 fiscal year, SARCAN collected and recycled approximately 242.8 million designated beverage containers. The overall recovery rate for all non-refillable designated beverage containers is approximately 87%.
- The Scrap Tire Management Program is authorized by *The Scrap Tire Management Regulations*. It is an industry stewardship program dedicated to the collection and recycling of tires to mitigate the impacts that scrap tires have on the environment. In 2004, the Saskatchewan Scrap Tire Corporation, which operates the program, collected and recycled over 635,000 tires of all sizes, equivalent to 26.4 million pounds or 1.3 million passenger car tires. This represents a capture rate of 70% against new tires sold. Phase Two of the program, the cleanup of scrap tires stockpiled at registered landfills, continued with tires removed from 35 landfills which service a total of 150 communities.

- The Used Oil Material Recycling Program is an industry stewardship program designed to establish a province-wide used oil recycling program that meets *The Used Oil Collection Regulations* and that maximizes the cost-effective collection of oil, filters and containers (Saskatchewan Environment 2004b). In 2004 the Saskatchewan Association for Resource Recovery Corporation collected more than 16.57 million litres of used oil, 1.89 million used oil filters and 248,974 kilograms of oil containers. The program has encouraged the development of over 350 used oil collection facilities that consumers can use in more than 200 communities across the province.
- The Paint Recycling Program, an industry stewardship program which began implementation in April 2006 under the authority of *The Waste Paint Management Regulations*, is designed to establish a province-wide used paint recycling program. The goal of the program is to reduce the disposal of paint in landfills or sewers and the environmental effects of these disposal practices (Saskatchewan Environment March 23, 2006). This being a new program, no performance measures will be available until the end of 2006.
- The Pesticide Container Collection Program has no legislation and is a voluntary program operated by Crop Life Canada Ltd. It was initiated to reduce the environmental impacts that agricultural pesticide containers may have on the environment. In 2004 a total of 1,921,500 plastic pesticide containers were collected and recycled.
- In 1992 Saskatchewan Environment initiated a $1.75 million cost-shared program with municipalities to assess the feasibility of regional waste management in Saskatchewan. As a result, the Regional Authority of Carlton Trail (REACT) was established in the Humboldt area. The provincial government followed up on the success of this program by supporting the establishment of eight additional regional waste management authorities through the Centenary Fund. This fund provided a total of $2.3 million over four years (2000-2004) to assist with start-up costs. Today a total of thirteen regional waste management authorities exist in the province serving over 150,000 people, representing over 15 per cent of the provincial population.
- To date, the Province and municipalities have jointly invested over $8 million in regional waste management in Saskatchewan. This investment has assisted in achieving the goals of reducing the amount of waste going into landfills and decreasing the number of landfills in the province that may have the potential to impact the environment (i.e. affecting air quality by burning waste, contamination of groundwater from poor landfill siting, illegal disposal and littering, etc.).

It is estimated that together all these initiatives have helped Saskatchewan achieve a 26.5% reduction in waste disposal rates per capita between 1988 and 1998. This is a significant accomplishment considering that during the same time period Saskatchewan's GDP grew by 39.8%, also increasing the amount of waste being generated. However, despite the increased waste generation, the province still managed to reduce the amount of waste being sent for disposal on a per capita basis.

Contaminated Sites Indicator

The issue

Contaminated sites are areas that have concentrations of one or more substances that are: 1) greater than background (normally occurring) concentrations and have the potential for immediate or long-term adverse effects to human health or the environment; or 2) in excess of those specified in policies and regulations (Government of Canada's Contaminated Sites Management Working Group 1995). The environmental concerns associated with contaminated sites include the potential for leaching of the contaminant(s) to ground or surface waters and/or the uptake and bioaccumulation of the contaminant(s) by plants or animals.

Contaminated Sites Indicator in Saskatchewan

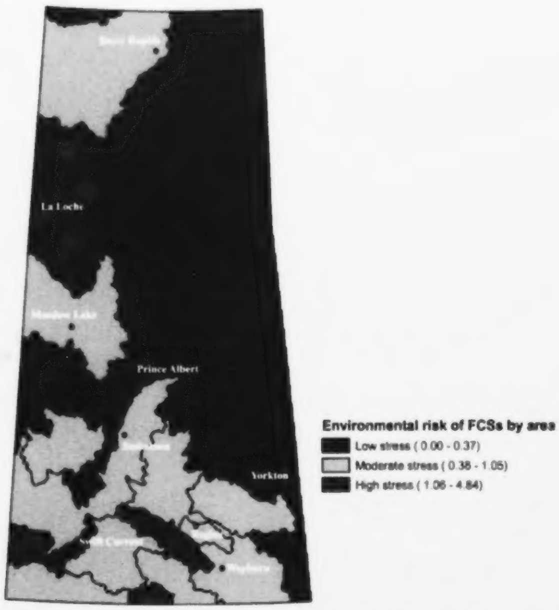


Figure 56. Density of federal contaminated sites in Saskatchewan, as listed on the Federal Contaminated Sites Inventory.

The Federal Contaminated Sites Inventory lists 157 contaminated sites that have been identified in Saskatchewan as either being on federal land or on non-federal land for which the Government of Canada has accepted some or all financial responsibility. The contaminant type has been identified for 86 of the 157 sites. Contaminants include: petroleum hydrocarbons; metals, metalloids and organometallics; energetics; heavy metals; toxic organics; other organics; benzene, toluene, ethylbenzene, and xylene; polycyclic aromatic hydrocarbons; nuisance substances; biological/chemical warfare agents; and physical/chemical (pH, temperature, dissolved solids, turbidity, etc.).

The watersheds with the highest potential stress are the Cypress Hills North Slope, Poplar River and Moose Jaw River Watersheds.

Indicator

Environmental Risk of Contaminated Sites by Watershed $= \dfrac{\sum[(\text{Number of contaminated sites}) \times \text{Site classification}]}{\text{Area of watershed (ha)}}$

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to identify the natural breaks in the data.

Environmental Stress of Contaminated Sites

Low stress: Environmental stress of contaminated sites is less than 0.37.

Moderate stress: Environmental stress of contaminated sites ranges from 0.37 and 1.05.

High stress: Environmental stress of contaminated sites is greater than 1.05.

Data Source: Federal Contaminated Sites Inventory.

Data Handling: For the contaminated sites obtained from the Federal Contaminated Sites Inventory the environmental risk class is calculated using the Contaminated Site Classification Categories, where: Class 1 (Action required) = 4; Class 2 (Action likely required) = 3; Class 3 (Action may be required) = 2; and Class N (Action not likely required) = 1. If the Contaminated Site Classification Category is either undefined or Class I (insufficient information - the Contaminated Site Classification Category is currently unknown) the environmental risk = 2, as there is potential for action to be required.

Data Discussion: Saskatchewan Environment has approximately 8,000 records on contaminated sites in Saskatchewan that are not part of the Federal Contaminated Sites Inventory. Currently, the contaminated sites information for Saskatchewan is not in an electronic format. Data on spills in Saskatchewan are in an electronic format. Access to both of these data sources would improve the reporting of this indicator.

Response to the issue

Saskatchewan Environment regulates provincial contaminated sites through The Environmental Management and Protection Act, 2002.

Legislation has been developed to reduce the environmental impacts of contaminated sites and to ensure that the contaminated site is not abandoned. Federal legislation that applies to the management of contaminated sites includes the *Canadian Environmental Protection Act, 1999* and *Regulations*, the *Fisheries Act*, and the *Canadian Environmental Assessment Act*.

In addition to legislation, Saskatchewan Industry and Resources administers a number of guidelines related to spills, contaminated sites and waste disposal from upstream oil and gas operations. These include: the Spill Site Reclamation Guidelines; the Upstream Contaminated Sites Remediation and Environmental Site Assessment Guidelines; the Drilling Waste Management and Frac Fluid and Sand Disposal Guidelines; and the Interim Draft Industrial Landfilling Requirements for Wastes Generated from Upstream Oil and Gas Industry.

Saskatchewan Environment established the Provincial Enforcement Centre Spill Report Line to receive and record province-wide reports of spills and environmental emergencies. The Provincial Enforcement Centre staff can provide advice on reported spills and confirm if containment and cleanup measures are adequate.

In 1995, the Government of Canada established the Contaminated Sites Management Working Group to identify, assess and manage federal contaminated sites. The Contaminated Sites Management Working Group is currently co-chaired by Environment Canada and the Department of National Defence and Canadian Forces, and currently comprises 15 federal departments and agencies which cost-share the activities.

As of July 2000, the federal government, under the Treasury Board Federal Contaminated Sites and Solid Waste Landfills Inventory Policy, requires all custodian departments and agencies to establish and maintain a database of their contaminated sites. This information must be submitted, at least once a year, to the Treasury Board of Canada Secretariat for incorporation into the Federal Contaminated Sites Inventory.

Each contaminated site in the Federal Contaminated Sites Inventory has been or will be classified into one of five classes based on the National Classification System for Contaminated Sites (Canadian Council of Ministers of the Environment 1992).

Industrial Waste Indicator

The issue

Industrial waste is defined as any substance discharged, emitted, or disposed into the environment that originates through industrial manufacturing or chemical processing. Industrial waste discharge constitutes a variety of substances, both organic and inorganic, including nutrients and toxins that can alter the structure and function of aquatic and terrestrial ecosystems.

Industrial Waste Indicator in Saskatchewan

Figure 57. Density of industrial waste sites by watershed, as reported to the National Pollutant Release Inventory in 2003.

For the 2003 reporting year, 452 Saskatchewan facilities submitted substance reports to the federally-run National Pollutant Release Inventory (NPRI) for a total of 85 pollutants. Of the 452 facilities that reported, 68% were involved in mining and oil and gas extraction, 12% were involved in manufacturing, 12% were involved in transportation and warehousing, 6% were utilities and the remaining 2% were involved in agricultural industries, retail trade, wholesale trade, educational services, and public administration.

In 2003 the density of facilities that were legally required to report to the NPRI in Saskatchewan was highest in the Cypress Hills North Slope and the Upper Souris River Watersheds. Watersheds with between 15 and 39 industrial waste facilities included the Battle River, Beaver River, Eagle Creek, and North Saskatchewan River Watersheds. The remaining Saskatchewan watersheds each had fewer than 15 facilities that were legally required to report to the NPRI.

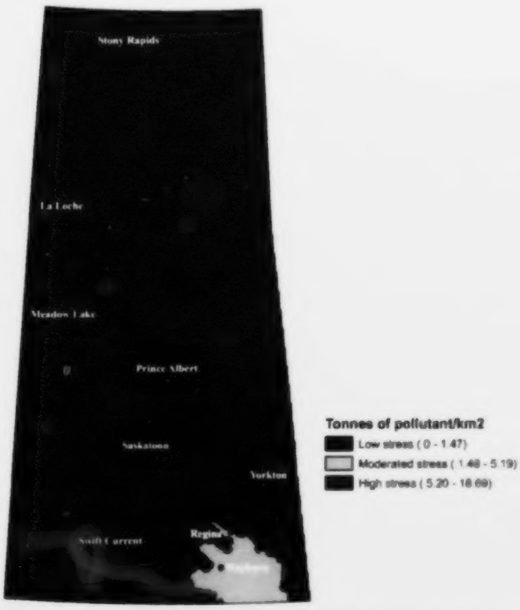


Figure 58. Tonnes of pollutants released and disposed of by watershed, as reported to the National Pollutant Release Inventory in 2003.

In 2003, the industrial facilities legally required to report to the NPRI in the Upper Souris River, Wascana Creek and Poplar River Watersheds released and disposed of 104,575, 61,634, and 57,911 tonnes of pollutants, respectively (Figure 58).

Industrial point source discharge of waste to waterways poses a direct threat to source water in Saskatchewan. In addition to nitrogen and phosphorus, industrial effluent from facilities who reported to NPRI in Saskatchewan also consisted of a mixture of 44 other chemicals, all of which have the potential to impact water quality.

Indicator		
Density of National Pollutant Release Inventory Facilities that Produce Industrial Waste	=	Number of National Pollutant Release Inventory facilities that produce industrial waste per watershed / Total area of watershed (km^2)
Tonnes of Pollutants Released and Disposed of by Watershed	=	Tonnes of pollutants released and disposed of by watershed from National Pollutant Release Inventory facilities / Total area of watershed (km^2)

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to identify the natural breaks in the data.

Density of NPRI Facilities that Produce Industrial Waste
Low stress: Density of industrial waste sites is less than 1.03/ 1,000 km^2.
Moderate stress: Density of industrial waste sites is 1.03 to 3.63/1,000 km^2.
High stress: Density of industrial waste sites is greater than 3.63/1,000 km^2.
Tonnes of Pollutants Released and Disposed of by Watershed
Low stress: Industrial waste is less than 1.48 tonnes/km^2.
Moderate stress: Industrial waste is between 1.48 and 5.19 tonnes/km^2.
High stress: Industrial waste is greater than 5.19 tonnes/km^2.

Data Source: Industrial waste site locations and tonnes of pollutants released and disposed of were obtained from the 2003 National Pollutant Release Inventory (NPRI) Database.

Data Quality/Caveats: This indicator includes only data on waste that was generated within Saskatchewan.

Data Discussion: Data are collected by the National Pollutant Release Inventory annually. However, it takes approximately a year after the data are reported for data quality checks to be completed.

Response to the issue

Saskatchewan Environment regulates industrial waste in Saskatchewan through *The Clean Air Act* and *Regulations*, *The Environmental Management and Protection Act, 2002*, and *The Water Regulations, 2002*.

In addition to legislation to regulate the release of industrial pollutants, Environment Canada established the National Pollutant Release Inventory (NPRI). The purpose of the NPRI is to monitor the releases and transfers of pollutants from industrial sectors in Saskatchewan. The NPRI was established in 1992 under the *Canadian Environmental Protection Act, 1999* (CEPA 1999). The NPRI collects information on the releases, disposal and transfers of pollutants from industrial sectors that meet the NPRI's established reporting criteria.

Industrial sectors that report to the NPRI include crude petroleum and natural gas, chemical and chemical products, paper and allied products, utilities, and metal mining.

Industries that are legally required to report to the NPRI include facilities that:

- use 10 tonnes or more per year of a core substance identified by NPRI in their manufacturing or processing facility and more than 20,000 employee work hours at the facility during the year;
- use, manufacture, or processes 50 kgs or more per year of polycyclic aromatic hydrocarbons (PAHs) and more than 20,000 employee work hours at the facility during the year;
- use dioxins, furans or hexachlorobenzene;
- release 20 tonnes or more of criteria air contaminants, which includes carbon monoxide, nitrous oxides, sulphur dioxide and total particulate matter less than 100 microns; or
- release 10 tonnes or more per year of volatile organic compounds.

The NPRI does not collect information on pollutants from:

- mobile sources such as vehicles;
- certain sector activities such as agriculture, education, and some mining activities; or
- facilities that release pollutants on a smaller scale.

Wetland Loss Indicator

The issue

Saskatchewan wetlands south of the boreal forest continue to be drained. The degree of wetland drainage varies between regions in Saskatchewan. The percentage of historic wetlands that have been drained is unknown at large scales. Wetland drainage occurs for a number of reasons, including urban development, transportation corridors and agricultural land use. Some of the perceived benefits of wetland drainage accrued by producers include earlier seeding dates, increased seeded acreage, and decreased nuisance costs (machinery/seed/input/time costs of seeding around wetlands). The environmental benefits of wetlands include: water storage and flood reduction; groundwater recharge; nutrient assimilation; wildlife habitat; sediment removal; reduction of pathogens; and the removal of contaminants, but the magnitude of these benefits within southern Saskatchewan have yet to be measured.

Wetland Loss Indicator in Saskatchewan

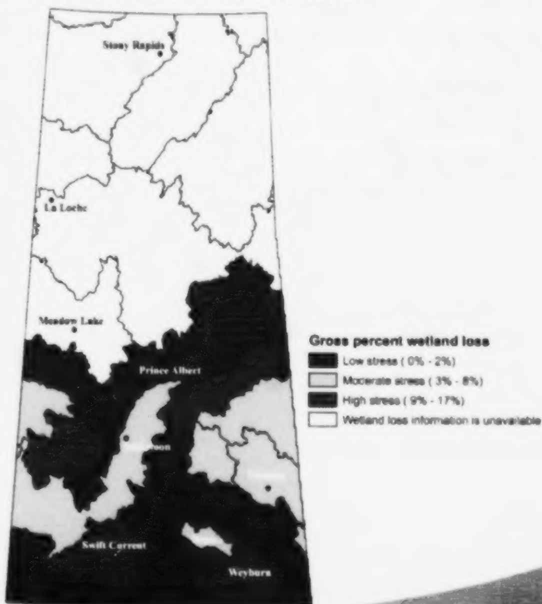


Figure 59. Estimated gross percent of wetland area loss by watershed from 1985 to 1999.

Source: Watmough 2006.
Note: The low, moderate and high stress levels are relative values, as at what point "high" stress occurs is unknown.

The gross wetland loss from 1985 to 1999 is estimated to be greatest in the Carrot River, Eagle Creek, Old Wives Lake, Swift Current Creek and Upper Souris River Watersheds. However, other watersheds in the province where considerable activities that result in wetland loss are thought to have occurred include the Assiniboine River and Lower Souris River Watersheds. The average wetland loss in Saskatchewan between 1985 and 1999 is estimated at 4.65%.

Currently there are no estimates at the provincial scale of wetland loss prior to 1985. This indicator only reflects the total drainage that has occurred within Saskatchewan between 1985 and 1999. The effects of the long-term, cumulative drainage within Saskatchewan is currently unknown, and more study in this area needs to be conducted.

Indicator		
Estimated Wetland Loss	=	Estimated gross percent of wetland area loss between 1985 and 1999 (Watmough 2006).

Rating Scheme

Estimated Wetland Loss
Low stress: Estimated wetland loss is less than 2%.
Moderate stress: Estimated wetland loss ranges from 3% to 8%.
High stress: Estimated wetland loss is greater than 8%.

Data Source: The data used to create this indicator were customized (Watmough 2006) from those obtained from the Environment Canada Prairie and Northern Habitat monitoring program.

Data Handling: The purpose of the Environment Canada Prairie and Northern Habitat monitoring program is to serve as a long-term monitoring program to evaluate trends in habitat loss within the Prairie Habitat Joint Venture target areas. For an overview of the Environment Canada Prairie and Northern Habitat monitoring program please refer to Watmough et al. 2002.

Response to the issue

The Saskatchewan Wetland Policy implemented by provincial government departments and agencies and led by the Saskatchewan Watershed Authority promotes the "sustainable management of wetlands on public and private lands" (Lynch-Stewart et al. 1999) (see **Legislative tools, strategies, policies and guidelines**).

The Saskatchewan Watershed Authority is currently developing a new Wetland Conservation and Drainage Management Policy to direct the Authority's work. The primary objectives of this policy development process are to ensure that issues surrounding drainage management and wetland conservation are addressed so as to effectively meet three of the mandated activities of the Authority: to manage drainage in the province; to protect source water and watershed health; and to coordinate the North American Waterfowl Management Plan on behalf of the Province. To promote an approach that balances environmental, economic and social interests, the policy development has included ongoing discussions with many interested organizations, including agriculture, industry, and conservation groups, and Aboriginal, local, and federal governments. It is anticipated that over the next six months the Authority will finalize the policy, after a final review by other government agencies and stakeholder organizations.

To conserve wetlands, programs such as the North American Waterfowl Management Plan (NAWMP) have been initiated. The North American Waterfowl Management Plan is an agreement between the United States, Canada and Mexico to conserve wetland and upland habitat for the promotion of migratory bird populations. To deliver the NAWMP in Canada's three Prairie Provinces, the Prairie Habitat Joint Venture (PHJV) was established. The PHJV is a partnership initiative with over 340 conservation partners. As of January 2006, the PHJV had secured/influenced 5.4 million acres of wetland and upland habitat, and 3.6 of the 5.4 million acres were secured after 1986 (Prairie Habitat Joint Venture 2006).

The National Round Table on the Environment and the Economy (NRTEE), in partnership with Statistics Canada, Natural Resources Canada - Canada Centre for Remote Sensing, the Canadian Space Agency and Environment Canada, is in the process of developing an indicator to measure the extent of wetlands in Canada. However, the current data limitations prevent a national overview of wetlands due to insufficient national

coverage, and inconsistent time lines and data collection standards (The National Round Table on the Environment and the Economy 2003). This NRTEE-led effort to begin a wetland inventory for Canada would be of significant help to Saskatchewan's wetland knowledge base.

Ducks Unlimited Canada, the Saskatchewan Watershed Authority, Agriculture and Agri-Food Canada, Saskatchewan Agriculture and Food, Saskatchewan Environment, Environment Canada, and the Nature Conservancy of Canada, as well as other non-government organizations, have information and programs related to wetland conservation and restoration.

It is recognized that this current indicator has limitations, and will be improved upon in future State of the Watershed Reports.

Invasive Exotic Species Indicator (under construction)

The issue

Invasive exotic species are noxious non-native species that, due to human intervention, have spread beyond their natural distribution. Invasive exotic species can dramatically alter the species composition and diversity of ecosystems through competition, predation and habitat alteration.

Response to the issue

In 2002, in response to the threats that invasive species are causing to Canada's ecosystems, the Canadian Food Inspection Agency, in conjunction with federal, provincial and territorial governments, released the document entitled *"An Invasive Alien Species Strategy for Canada"*. The four main goals of the strategy are to:

- prevent introductions of invasive species;
- detect and identify new invaders;
- respond to invaders in a timely manner; and
- manage invaders effectively (Canadian Food Inspection Agency 2002).

The Canadian Food Inspection Agency is also currently in the process of developing a Canadian Invasive Plant Strategy and plans to release this document in October 2007.

Saskatchewan Agriculture and Food regulates noxious weeds in Saskatchewan through *The Noxious Weeds Act, 1984* and *The Pest Control Act*.

The Noxious Weeds Act, 1984 and *The Pest Control Act* mandate that every owner or occupant of land in Saskatchewan must destroy and prevent the spread of noxious weeds or pest species. To carry out the enforcement component of these Acts municipalities appoint weed inspectors.

The Noxious Weeds Designation Regulations of Saskatchewan lists 41 noxious weeds. Three of the 41 noxious weed species are native to Saskatchewan; therefore, thirty-eight of these of these are considered non-native invasive species.

The Pests Declaration Regulations, administered by Saskatchewan Agriculture and Food, list four pests in Saskatchewan, including:

- the brown or Norway rat [*Rattus norvegicus* (Erxleben)];
- Dutch elm disease, caused by the fungus *Ophiostoma ulmi;*
- grasshoppers; and
- the warble fly.

In addition to legislation, invasive species programs have been initiated in the province to identify and control the distribution of invasive species. Some of the invasive species programs in Saskatchewan include:

- The Saskatchewan Purple Loosestrife and Invasive Species Project, established in 1996 to: educate the public on invasive species in Saskatchewan; conduct inventories of invasive species in Saskatchewan; determine the noxious weed status of Saskatchewan; and create and promote eradication and control strategies for the identified invasive species.
- The Noxious Weed Management Program, initiated in 1999 by the Government of Saskatchewan to control the spread of noxious weeds such as scentless chamomile, leafy spurge, yellow toadflax and purple loosestrife (Bowes 2003). Noxious weed occurrences within rural municipalities where weed inspectors are appointed are recorded and entered into the RDI database as part of the Noxious Weed Management Program.
- The Shifts in the Distribution, Abundance, Resistance, and Management of Weeds in Prairie Ecosystems Project was initiated in 2001 by Agriculture and Agri-Food Canada to: conduct weed counts in 4,000 randomly selected annually cropped fields in Canada's three prairie provinces; gather details on the farm practices of the surveyed fields; and to look for resistant weeds in some of the surveyed fields (Leeson et al. 2003).

7.3 Response Indicators

Water Conservation Indicator

The issue

Some of the benefits of efficient water use include improving water quality, maintaining aquatic ecosystems, sustaining economic growth and protecting drinking water resources.

A water conservation strategy for Saskatchewan has been developed by the Saskatchewan Watershed Authority in consultation with the public and interest groups. The resulting water conservation plan encourages all sectors (municipal, industrial, and agricultural) to strive towards efficient water use.

There is a broad range of water conservation tools that will be employed within Saskatchewan's Water Conservation Plan, including: 1) communication and educational tools; 2) operational and maintenance tools; 3) economic and financial tools; and 4) institutional support.

Examples of water conservation measures include:

- **Providing educational information on water conservation to the public.**
  Experts within industry have stated that water conservation is a generational shift in attitudes. It is important to start educational/ extension activities at an early stage of any water conservation plan.
- **Universal metering.**
  Employed with a volume-based pricing structure, water metering is a good water conservation practice, as it provides a measure of the actual water use of consumers. According to the 2001 Environment Canada Municipal Water Use Survey, of the 78 Saskatchewan municipalities that responded to the survey, 98.5% of residential clients and 99.6% of business clients served by municipal water systems were metered. Saskatchewan had the highest percentage of residential clients that were metered according to the 2001 Municipal Water Use Survey results.
- **Water accounting and loss control.**
  This measure will encourage communities to conduct water leak audits. By conducting a water audit communities will be able to determine water loss that may be due to water distribution system leaks.
- **Costing and pricing.**
  Water rate structures can promote conservation by communicating the true cost of water to the consumer through price incentives. The true cost of treated water includes the cost of the utility to operate, the cost of the utility to increase its water supply to meet growing demand, and the social and environmental costs caused by the water withdrawal. A typical example of a water rate structure that encourages conservation is implementation of an increasing rate structure (if an excessive volume of water is used, the price for the additional water is increased) compared to a stable rate structure (same cost per cubic metre regardless of how much is used).
- **Promoting the purchase and use of water efficient fixtures.**
- **Developing pilot projects with water efficient practices.**
- **Developing, in conjunction with industry associations, industry recommended practices (IRPs).**

Water Conservation Indicator in Saskatchewan

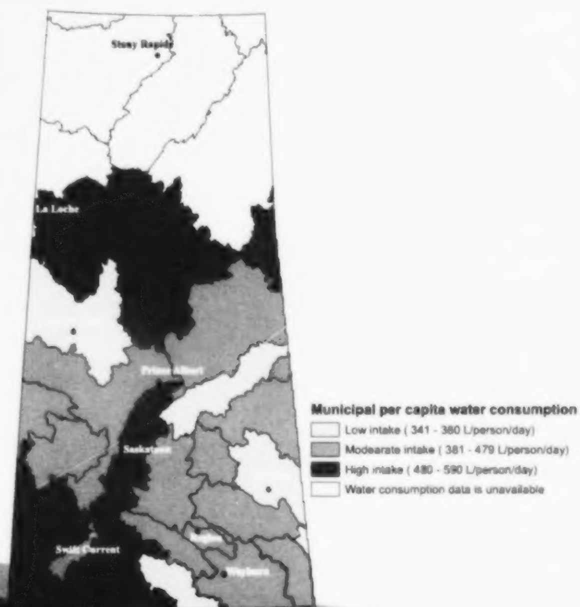


Figure 60. Estimate of per capita daily water consumption by watershed: 1994.

Twenty-one of the twenty-three watersheds that have water consumption data have, on average, an 11% decrease in per capita water consumption between 1994 and 2004. The South Saskatchewan River and Big Muddy Creek are the only two watersheds that have an increase in per capita water consumption, with 9% and 24% respectively.

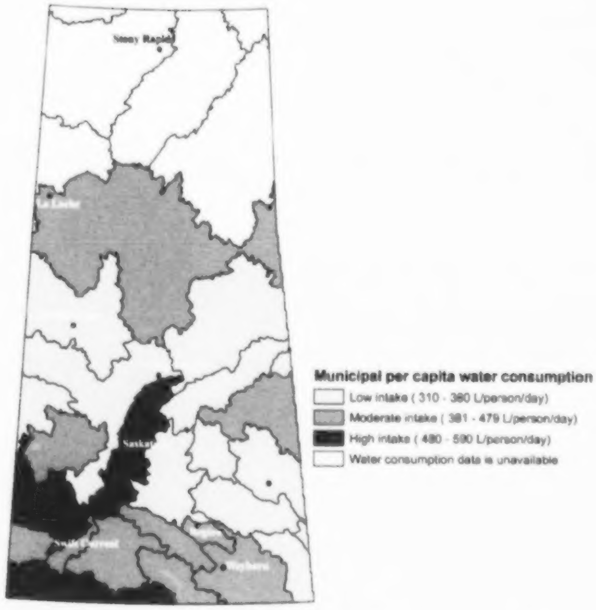


Figure 61. Estimate of per capita daily water consumption by watershed: 2004.

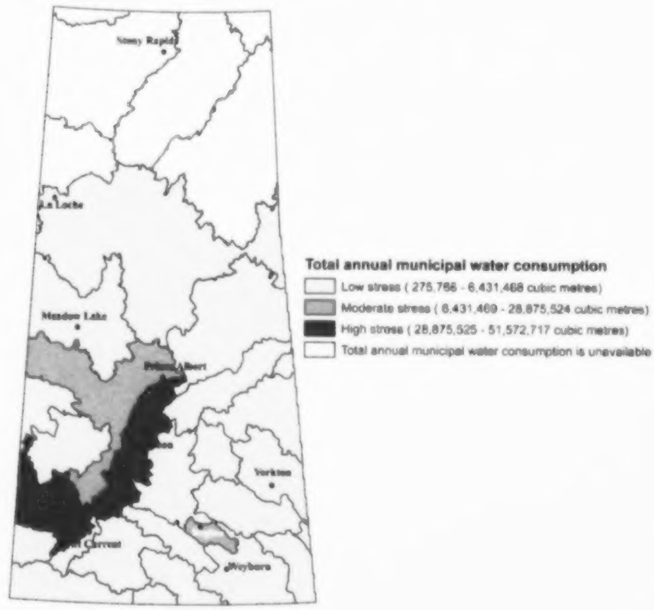


Figure 63. Estimate of annual total water consumption by watershed: 2004.

Total water consumption in Regina between 1994 and 2004 decreased 2.2%. For the entire province there was an 11.5% increase in the total amount of municipal water consumed.

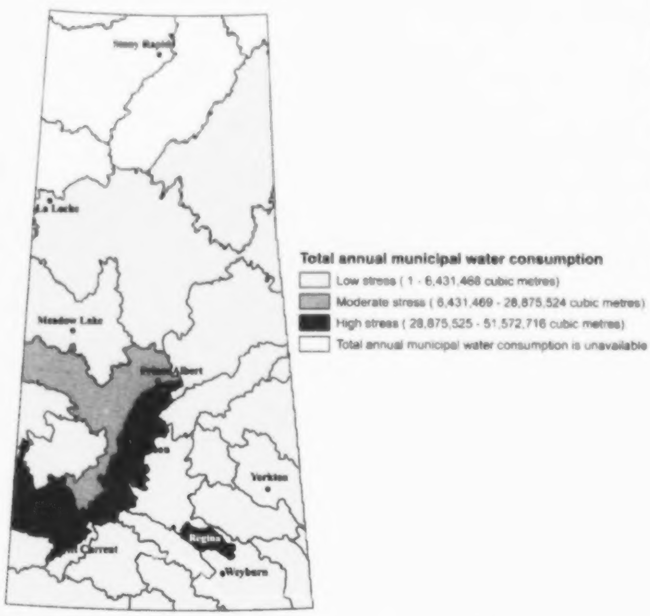


Figure 62. Estimate of annual total water consumption by watershed: 1994.

Figure 61. Estimate of per capita daily water consumption by watershed: 2004.

Figure 62. Estimate of annual total water consumption by watershed: 1994.

Twenty-one of the twenty-three watersheds that have water consumption data have an average [illegible] decrease in per capita water consumption between 1994 and 2004. The South Saskatchewan River and Big Muddy Creek are the only two watersheds that have an increase in per capita water consumption, with [illegible] and [illegible], respectively.

Figure 63. Estimate of annual total water consumption by watershed: 2004.

Total water consumption of [illegible] between 1994 and 2004 decreased [illegible] the total amount of municipal water consumed.

Table 9. Irrigation projects in the South Saskatchewan River Basin.

Irrigation project	Year	Irrigated acres	Irrigated volume (Acre feet)	Irrigated feet
SSRID	2003	33,419.70	41,246.50	1.23
Gravity Open Ditch	2004	33,456.80	24,440.50	0.73
	2005	30,617.80	13,805.00	0.45
Riverhurst	2003	9,538.30	9,080.27	0.95
Pressurized	2004	9,869.60	4,411.42	0.45
	2005	9,981.90	4,333.90	0.43
Luck Lake	2003	8,602.20	3,407.83	0.40
Pressurized	2004	8,602.20	8,252.90	0.96
	2005	9,044.90	3,075.30	0.34

To promote sustainable irrigation through research and demonstration projects, the Canada-Saskatchewan Irrigation Diversification Centre was established.

Indicator

An efficiency measure of water uses such as irrigation, municipal, and industrial water uses will provide historic baseline water use information.

Municipal Conservation	=	Daily municipal use per capita / Municipal population
Irrigation Conservation	=	Irrigation (dam) / Irrigated acres
Industrial Conservation	=	# of industries implementing Industry Recommended Practices / # of Industry Recommended Practices completed

Due to the inconsistencies in how irrigation is monitored, it makes sense to provide a qualitative overview of the delivery methods used in a watershed and to describe the advantages of water conservation strategies (e.g. low pressure sprinkler systems may be better for conservation than high pressure sprinkler systems).

Data Source: The water consumption data were obtained from the Saskatchewan Watershed Authority's Community Consumption Database. Population information was obtained from the Saskatchewan Health Covered Population 2004 document (Government of Saskatchewan 2004b).

Data Quality/Caveats: The population data in the Community Consumption Database were not available for all communities (e.g. provincial parks). Per capita water consumption calculations were only calculated for communities with a population greater than zero (some provincial parks and recreational areas have a population of zero). Total water consumption values are only for the communities that report to the Community Consumption Database. Therefore, the total water consumption values are not for the entire population in the watershed, as many rural residents rely on private wells which do not report to the Community Consumption Database.

Data Discussion: Irrigation data are often available for the largest irrigation projects, as shown for the three large irrigation districts in the South Saskatchewan River Basin. The new metering and billing database of SaskWater may have some potential for this indicator.

Consideration must be given to drought situations that may create a false measurement of any conservation. If water supplies are adequate, irrigation will increase during meteorologic drought, thereby falsely indicating reduced conservation. When water supplies are inadequate or during periods of adequate or surplus growing season precipitation, irrigation water use will be lower, falsely indicating increased water conservation efforts. Time-series analysis of water consumption may eliminate or at least reduce these errors. With municipal conservation, attention must be paid to whether source water is surface or groundwater, and also the accuracy of actual watershed source (i.e. some communities within a watershed may receive source water from an adjacent watershed).

Watershed Education Indicator

The issue

This indicator reports on the number and type of watershed-related educational programs delivered to school-aged youth. Sustainable watershed management is premised on stakeholders being knowledgeable about their watershed. Educational programs can raise awareness of watershed issues and change the values and beliefs that people hold on watershed resources. This attitudinal change prefaces behavioural change; people generally try to be consistent in their attitudes and behaviours. The linked behavioural changes are fundamental to promoting sustainability, as the impact of the cumulative actions of individual and group stakeholders in a watershed outweighs those under the Saskatchewan Watershed Authority's direct management.

The success of a watershed education program is measured through increased awareness of watershed issues and behavioural change to support improvements in watershed condition.

Watershed Education Indicator in Saskatchewan

Some of the ongoing watershed education programs initiated in Saskatchewan include:

1) Project WET (Water Education for Teachers) and Project WILD are complementary environmental education programs. They provide teaching methods and instructional resource materials for educators to use in promoting an awareness and understanding of healthy ecosystems, stewardship of water resources and responsible environmental citizenship.

   The primary audiences for these environmental education programs are classroom teachers and pre-service teachers. Saskatchewan Learning recognizes and authorizes the use of these materials in teaching the Core Science curriculum from Grades One to 12. All of the materials for these programs are directly linked to the science curriculum. These instructional resource materials also support the provincial social studies, mathematics, language arts, fine arts, health, and practical and applied arts curricula.

Table 10. Environmental education events for Saskatchewan school-aged youth (4-18 years-old) and teacher/parent supervisors: July 2005 to June 2006.

Program	Number of events	Number of participants
Project WILD	1	12
Project WET	21	1,308
Project WET – Splash!	3	469
Totals	25	1,789

Table 11. Presentations about Saskatchewan environmental education programming to water resource professional groups: July 2005 to June 2006.

Number of professional groups	Number of participants
3	124

Table 12. Professional development programs for educators in Saskatchewan: July 2005 to June 2006.

Workshop type	WILD	WILD- Below Zero	WET	Native Prairie Curricula	Totals
Certification (1 day)	6	N/A	14	N/A	20
Participants	123	-	273	-	393
Certification (0.5 day)	7	10	N/A	N/A	17
Participants	168	307	-	-	475
Leadership Development and/or Curriculum Writing (0.5-3 days)	2	1	2	N/A	5
Participants	42*	13*	42*	-	97*
Total Workshops					42
Total Participants					968

*Almost all facilitators are certified to present more than one program. A number of facilitators who completed basic leadership development in July and August 2005 also took advanced leadership development in April 2006.

Table 13. Active facilitators: July 2005 to June 2006.

Program	Number of facilitators**
Project WILD	37***
Project WILD – Below Zero*	17***
Project WET – Splash!	41***
Total Number of facilitators	95***

** Active facilitators are those facilitators who delivered workshops or who took facilitator training during the given academic year. Additional educators have previously qualified but have not been active in the given academic year.
*** Almost all facilitators are certified to present more than one program and are therefore counted in all applicable categories. The strategic goal for the 2005-06 academic year was to train the existing facilitators in more than one program.

2) Ducks Unlimited Canada's Saskatchewan Wetland Education Program was designed for Grades One to Eight, and was initiated in the 1999-00 school year. This program includes Ducks Unlimited staff-led wetland field trips and/or in-class lesson plans on wetlands. The new name for the Saskatchewan Wetland Education Program is Project Webfoot.

During the 2005-06 fiscal year the Project Webfoot school presentations and field trips, delivered by wetland educators on contract to Ducks Unlimited Canada, reached 3,737 students, 235 parents or adult supervisors and 249 teachers/teaching assistants, for a total of 4,221 individuals.

Ducks Unlimited Canada has been offering these educational programs since 1999. Between 1999 and March 2005 the educational programs have been delivered to a total of 51,422 students and 5,516 adults. The delivery mechanism for these programs has been 2,255 class presentations or field trips in 959 schools throughout Saskatchewan.

In addition to Saskatchewan's Wetland Education Program, Ducks Unlimited also has the Greenwing Program. The Greenwing Program is a membership-based program geared to school aged youth. Membership in the Greenwing Program includes a certificate of membership, a subscription to either *Puddler* magazine (aged 12 and under) or *Conservator* magazine (12-17 years old), and a copy of the *Marsh World* wetland guidebook.

There are currently 8,094 Greenwing members in Saskatchewan. Of the 8,094 members, 7,760 members have become Greenwing members through Project Webfoot class sponsorships and 334 have annual or Legacy Greenwing memberships.

Table 14. Ducks Unlimited's Greenwing members.

Fiscal Year	Greenwing members in Saskatchewan *
1995-1996	197
1996-1997	566
1997-1998	881
1998-1999	1,050
1999-2000	1,067
2000-2000	843
2001-2002	583
2002-2003	554
2003-2004	464
2004-2005	487
2005-2006	334

* includes Legacy, senior and junior members but not Adopt-A-Class or school-based programs.

3) The Saskatchewan Prairie Conservation Action Plan delivers the Cows, Fish, Cattle Dogs and Kids Game Show to Grades Four to Six. The game show is an educational game show about riparian areas. Funding for the game show is by a number of organizations, making it free of charge to participating schools in Saskatchewan's Prairie Ecozone.

Table 15. Prairie Conservation Action Plan Cows, Fish, Cattle Dogs and Kids Game Show: 1999 to June 2005.

School Year	Number of schools	Number of students
1999-2000	10	800*
2000-2001	22	1,900*
2001-2002	72	4,700*
2002-2003	176	8,375*
2003-2004	80	7,925*
2004-2005	21	1,310*
2005-2006	82	5,160*
Total	**463**	**30,170**

* Participation numbers listed in Table 15 do not include students that participated in the Game Show delivered at Agri-Ed events in Saskatoon (Fall Fair) and Regina (Agibition). Total student participation at these two events is approximately 1,200 to 1,500 students annually.

4) Partners FOR the Saskatchewan River Basin previously offered, free of charge, the Water Watchdog Program to stewardship groups in Manitoba, Saskatchewan, and Alberta. Partners FOR the Saskatchewan River Basin is currently in the process of pursuing funding to continue offering this program. The Water Watchdog Program is a hands-on program geared to young people (7-14 years old) involved in such organizations as Girl Guides, 4-H, Junior Forest Rangers, stewardship groups, and summer camps. The program incorporates a field trip to a local stream or lake to assess local water quality and riparian conditions. An estimated 200 different Prairie water bodies have been monitored by Water Watchdog groups. At least 1,800 adults have worked as Water Watchdog volunteer facilitators.

Table 16. Total participants in the Water Watchdog Program for Alberta, Saskatchewan and Manitoba.

Year	Number of participants
2001	580
2002	1,635
2003	8,550
2004	2,400
2005	560
2006*	350
Total	**13,725****

* Total until August 1, 2006
** Saskatchewan residents account for over 40% of the total participants.

In addition to the Water Watchdog Program, Partners FOR the Saskatchewan River Basin is in the process of developing a Basin Geography Board Game. The objective of the game is to:

- teach students about the greater Saskatchewan River Basin;
- explain how human activities can impact watershed health; and
- promote ecological stewardship and conservation for watersheds.

Indicator

Learning outcomes are difficult to measure. However, there are indirect predictors of learning outcomes that can be easily measured, the easiest being educational effort. The number of programs delivered to school-aged youth, or *Youth Programs*, provides a direct estimate of the number of youth exposed to watershed health-related modules. *Workshop Delivery* measures the number of delivered workshops and the number of attending facilitators. This provides an indirect measure of the potential number of youth exposed to watershed education modules. The number of *Active Facilitators* is an even more indirect predictor of learning outcomes than *Workshop Delivery*, but it does provide insight into how workshops are delivered and perhaps how sustainable that delivery is.

Programs included in this measure are: Project WET, Project WILD, and Climate Change Education Saskatchewan (CCES), offered by the Saskatchewan Watershed Authority; the Saskatchewan Wetland Education Program offered by Ducks Unlimited Canada; the Cows, Fish, Cattle Dogs, and Kids Game Show offered by the Prairie Conservation Action Plan; and the Water Watchdog Program offered by Partners FOR the Saskatchewan River Basin.

Data Source: Information on the number of participants in Project WET, Project WILD, and Climate Change Saskatchewan was obtained from the Saskatchewan Watershed Authority. Information on the number of participants in the Saskatchewan Wetland Education and Greenwing Programs was obtained from Ducks Unlimited Canada. Information on the number of participants in the Cows, Fish, Cattle Dogs, and Kids Game Show was obtained from the Saskatchewan Prairie Conservation Action Plan. Information on the number of participants in the Water Watchdog Program was obtained from the Partners FOR the Saskatchewan River Basin.

Data Quality/Caveats: The watershed education data can not be disaggregated by watershed. However, the existing data allow the educational response to be measured at the provincial scale.

Stewardship

Conservation Stewards Indicator

The issue

Conservation stewards play a key role in maintaining and conserving natural areas through land management decision-making.

Conservation Stewards Indicator in Saskatchewan

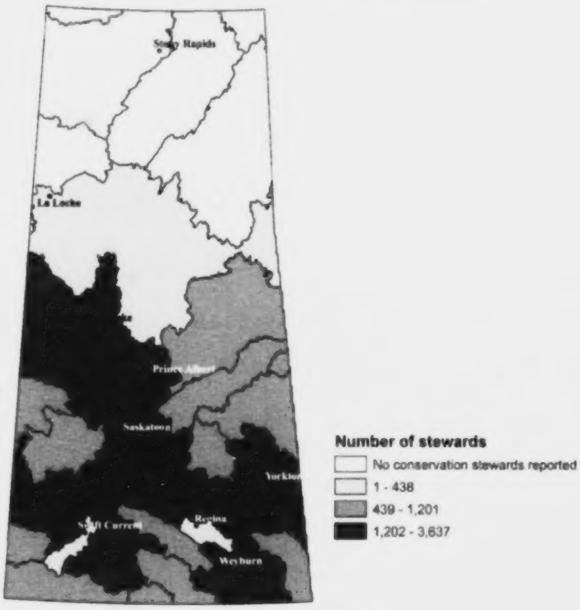


Figure 64. Number of stewards by watershed.

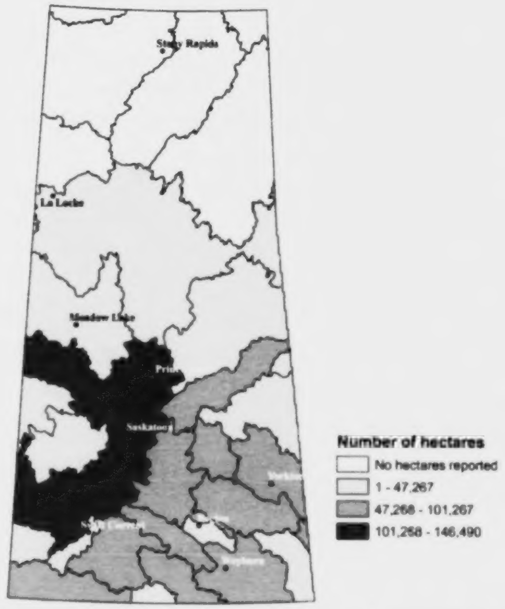


Figure 65. Number of hectares covered under conservation agreements by watershed.

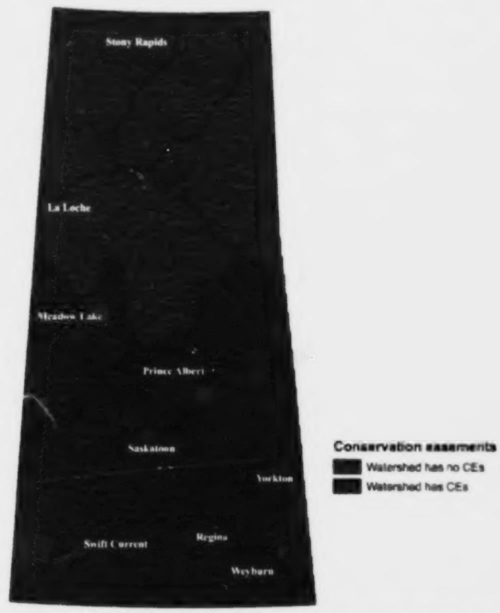


Figure 66. Conservation easement status by watershed: August 2006.

Stewardship

Conservation Stewards Indicator

The issue

Conservation stewards play a key role in maintaining and conserving natural areas through land management decision making.

Conservation Stewards Indicator in Saskatchewan

Figure 64. Number of stewards by watershed.

Figure 65. Number of hectares covered under conservation agreements by watershed.

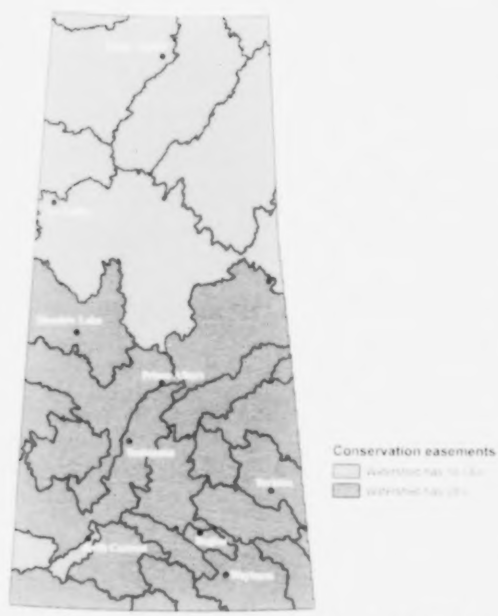


Figure 66. Conservation easement status by watershed: August 2006.

Twenty of Saskatchewan's 29 watersheds have at least one conservation easement.

Stewardship information included in this indicator is from a number of organizations, whose programs primarily focus on conservation stewards on private land that are in the agricultural areas of Saskatchewan. Therefore, there are currently no private conservation stewards or hectares reported for the northern watersheds. It should also be noted that approximately 65% of Saskatchewan is Crown land, and much of the Crown land is in the northern and central part of the province (Saskatchewan Environment 2006a). Stewardship information from other organizations and agencies will be included in this indicator as the data become available.

Currently, this indicator includes stewardship information about:

1) Voluntary stewards who made a verbal voluntary stewardship agreement under the Prairie Stewardship Program, a partnership program coordinated by the Saskatchewan Watershed Authority. Through the voluntary agreement the stewards agree to maintain and protect their native prairie and/or riparian areas to the best of their ability.
2) Conservation stewards who signed contracts with Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration (AAFC-PFRA) under the Permanent Cover Programs I and II and the Greencover Canada Program. The total number of stewards that have signed agreements under the Permanent Cover Programs I and II and the Greencover Canada Program Land Conversion Component as of February 1, 2006 is 6,346, for a total of 230,895 hectares converted to permanent cover. The Permanent Cover Program I (PCP I) was announced by AAFC-PFRA in 1989 as a three-year program to reduce the risk of soil erosion on marginal lands that had high erosion potential. An extension to the program was the Permanent Cover Program II (PCP II) which was delivered between 1991 and 1993. The Greencover Canada Program was initiated in 2001 under the Agricultural Policy Framework, a joint strategy developed by federal, provincial and territorial Ministers of Agriculture. The land use agreements under the Greencover Canada Program are 10-year commitments to maintain the land in perennial cover, and they come into effect once the perennial cover is established and inspected.

Table 17. Number of voluntary stewards and land area covered by the voluntary stewardship agreements under the Prairie Stewardship Program.

Year	Number of stewards	Hectares of Prairie	Hectares of wetland	Kilometres of stream
Pre-2002	759	128,906	1,504	80
2002	332	53,049	3,828	220
2003	104	25,736	652	97
2004	77	25,195	1,159	95
2005	69	20,234	365	168
2006	44	5,917	405	45
Total	**1,385**	**259,036**	**7,912**	**706**

3) Hectares that have been conserved through conservation steward agreements with Ducks Unlimited Canada. Since 1938, Ducks Unlimited Canada has partnered with landowners in Saskatchewan to conserve and restore wetland and upland habitats. Conservation efforts have focused on an array of programs, including forage programs, conservation easements and large wetland projects.

Table 18. Ducks Unlimited Canada's Project Summary for Saskatchewan.

Securement method	Total hectares
Grazing projects	89,974
Conservation easement projects	9,136
Prairie forage program	33,074
Large wetland projects	161,697
Total	**293,881**

4) Conservation stewards who signed land use agreements with Saskatchewan Agriculture and Food under the Conservation Cover Program. Between 2001 and 2003, the Conservation Cover Program (CCP) provided financial assistance to producers resulting in the conversion of 533,148 hectares of marginal cropland to perennial cover.

Table 19. Number of land use agreements signed under the Conservation Cover Program between 2001 and 2003.

Year	Agreements	Hectares converted
2001	10,792	105,066
2002	6,226	164,311
2003	4,016	263,779
Total	**21,034**	**533,148**

Source: Saskatchewan Agriculture and Food

Indicator		
Number of Conservation Stewards	=	Number of conservation stewards per watershed
Number of Hectares Under Conservation Agreements	=	Number of hectares under conservation agreements per watershed
Conservation Easements	=	Number of conservation easements per watershed

Rating Scheme

Number of Conservation Stewards
Gap = No conservation stewards reported in the watershed.
Present = At least one conservation steward reported in the watershed.
Number of Hectares Under Conservation Agreements
Gap = No hectares reported under conservation agreements in the watershed.
Present = At least one hectare under conservation agreements reported in the watershed.
Conservation easements by watershed
Absent/Gap = No conservation easement in the watershed.
Present = At least one conservation easement in the watershed.

Data Source: The number of conservation stewards who made a voluntary stewardship agreement as part of the Saskatchewan Watershed Authority's Prairie Stewardship Program was obtained from the Saskatchewan Watershed Authority's Landowner Information Database. The number of conservation stewards who signed contracts under the Permanent Cover and Greencover Canada Programs was obtained from AAFC-PFRA. The Ducks Unlimited information was obtained from Ducks Unlimited Canada. The number of conservation stewards who signed contracts under the Conservation Cover Program was obtained from Saskatchewan Agriculture and Food.

Data Discussion: The intention of this indicator is to map, by watershed, all of the agreements and hectares covered by the different land stewardship programs in Saskatchewan. Through the cooperation and collaboration of various organizations, we are currently in the process of obtaining data on additional programs with conservation stewards that will be included in this indicator.

Stewardship Workshops Indicator

The issue

The land management practices of landowners are critically important to healthy watersheds. Stewardship workshops can be organized to provide stewards with information on Beneficial Management Practices (BMPs), hands-on training to better understand land management through range and/or riparian assessments, and to showcase the management efforts of specific landowners through field tours.

Stewardship Workshops Indicator in Saskatchewan

1) *The Prairie Stewardship Workshops.* To increase the public's awareness of the importance, value, and function of riparian and native prairie ecosystems the Saskatchewan Watershed Authority, in partnership with other agencies, initiated the Prairie Stewardship Program in 2002. The Prairie Stewardship Program is an amalgamation of the Saskatchewan Wetland Conservation Corporation's (now the Saskatchewan Watershed Authority) Native Prairie Stewardship and Streambank Stewardship Programs. Both the Native Prairie Stewardship and Streambank Stewardship Programs were initiated in 1997.

Prairie Stewardship workshops include:

- field tours to view demonstration projects managed by landowners. Examples of demonstration projects include grazing management systems, perennial forage establishment, and corral/wintering site modifications.
- range and pasture schools to provide stewards with hands-on training in range or riparian assessments. These intense workshops provide landowners with detailed information on plant identification, ecology and management of riparian and upland ecosystems.

Table 20. Number of Prairie Stewardship Program field days/town hall meetings/workshops and attendance between April 2002 and March 2006.

	Year	Number of events	Attendance
Field days/town hall meetings	2002	19	470
Field days/town hall meetings	2003	6	164
Workshops/town hall meetings	2003	11	280
Workshops/town hall meetings	2004	21	542
Workshops/town hall meetings	2005	7	155
Workshops/town hall meetings/Field days	**2006**	**69**	**1,849**
	Total	**133**	**3,460**

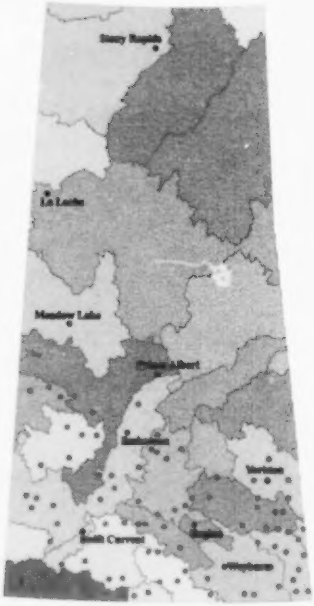


Figure 67. Locations of stewardship workshops delivered through the Prairie Stewardship Program between March 2001 and March 2006.

2) *The Environmental Farm Plan Workshops.* To promote Beneficial Management Practices (BMPs), Agriculture and Agri-Food Canada initiated the Environmental Farm Plan Program under the Agricultural Policy Framework (APF). In Saskatchewan, the Environmental Farm Plan Program is delivered by the Provincial Council of Agriculture Development and Diversification Boards for Saskatchewan Inc. (PCAB), in partnership with Saskatchewan Agriculture and Food and Agriculture and Agri-Food Canada. The Environmental Farm Plan Program is comprised of a series of two workshops (Workshop I and Workshop II) delivered by PCAB-trained facilitators, followed by a peer review process. The purpose of the Environmental Farm Action Plan is to increase the awareness of agricultural producers to some of the risks agricultural land use practices can have on the environment and to encourage producers to adopt BMPs to reduce these environmental risks.

The Environmental Farm Plan Program began in Saskatchewan in September 2004. As of June 30, 2006, there have been 461 Workshop I's with 7,142 participants involved, and 415 corresponding Workshop II's with 4,753 participants. Four-thousand five-hundred and forty-eight (4,548) Environmental Farm Plans have been submitted for peer review, and 4,473 of these plans were endorsed. Approximately 2,707 producers have submitted Action Plans under the Canada-Saskatchewan Farm Stewardship Program. Currently, twenty facilitators have been trained to deliver Environmental Farm Plan workshops.

ADD Board Regions and Districts

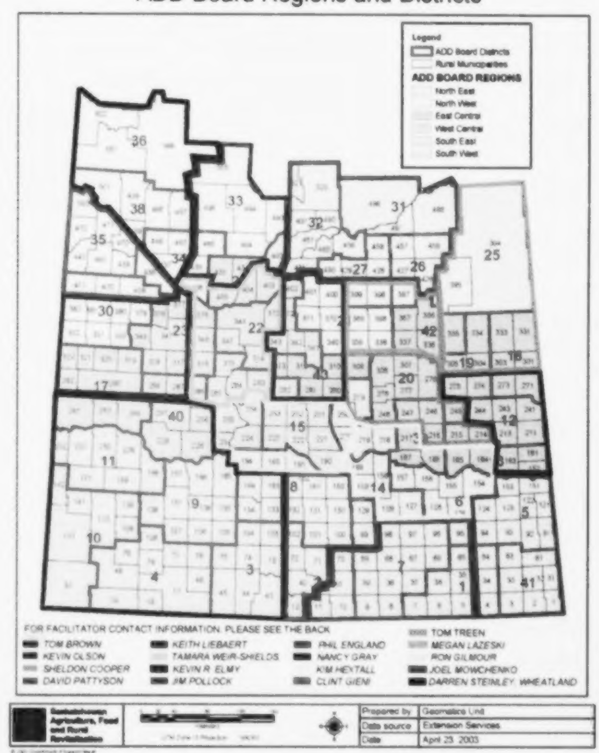


Figure 68. Saskatchewan's Environmental Farm Plan workshop delivery areas by PCAB facilitator: September 2005.

Source: http://www.saskpcab.com/locationmap.html

Figure 67. Locations of stewardship workshops delivered through the Prairie Stewardship Program between March 2001 and March 2006.

2) *The Environmental Farm Plan Workshops.* To promote Beneficial Management Practices (BMPs), Agriculture and Agri-Food Canada initiated the Environmental Farm Plan Program under the Agricultural Policy Framework (APF). In Saskatchewan, the Environmental Farm Plan Program is delivered by the Provincial Council of Agriculture Development and Diversification Boards for Saskatchewan Inc. (PCAB), in partnership with Saskatchewan Agriculture and Food and Agriculture and Agri-Food Canada. The Environmental Farm Plan Program is comprised of a series of two workshops (Workshop I and Workshop II) delivered by PCAB-trained facilitators, followed by a peer review process. The purpose of the Environmental Farm Action Plan is to increase the awareness of agricultural producers to some of the risks agricultural land use practices can have on the environment and to encourage producers to adopt BMPs to reduce these environmental risks.

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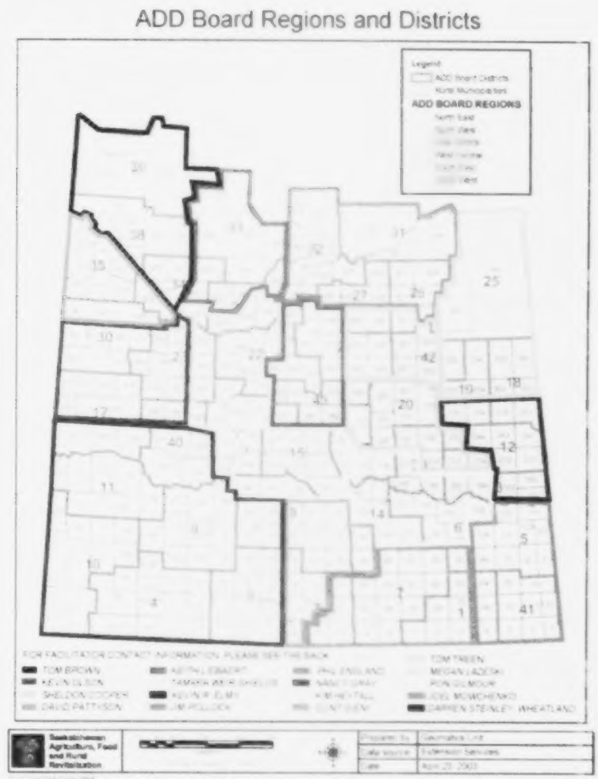

Figure 68. Saskatchewan's Environmental Farm Plan workshop delivery areas by PCAB facilitator: September 2005.

3) *The Saskatchewan Soil Conservation Association Workshops*. The Saskatchewan Soil Conservation Association (SSCA) is a non-profit, producer-based organization that actively promotes soil conservation in Saskatchewan through conferences, workshops, a quarterly newsletter, producer networking opportunities, and soil conservation extension materials. The SSCA hosts two conferences annually. In February, the SSCA hosts a Direct Seeding Conference geared to producers, and in December they host a conference geared to crop advisors in the livestock and grain sectors. In addition to the two annual conferences, SSCA staff are guest speakers at 90 to 100 workshops each year. As guest speakers they provide information on topics such as: crop residue management; crop rotations; weed control; soil fertility; equipment selection and retrofitting; and forages in rotation.

   The Saskatchewan Soil Conservation Association's Direct Seeding Conference in February is held in either Saskatoon or Regina. Approximately 650 people attend the conference. Of the 650 attendees at the most recent conference, 500 of the participants were farmers and the remainder of the participants were crop advisors (agrologists and agronomists), academics, and representatives from the agriculture manufacturing sector. Farmers come from all over the province to attend the conference, although historically more farmers from the north attend the conference when it is in Saskatoon, while more farmers from the south attend the conference when it is held in Regina.

4) *Manure Management Workshops*. A meeting in November 1998 brought together the three prairie provinces to discuss the opportunities for cooperating on research, development and extension activities in the area of manure management and livestock development.

   Saskatchewan Agriculture and Food published their Strategy for Manure Management in early 1999 (at www.agr.gov.sk.ca under livestock/pork/manure management). As a result of this coordination of effort there have been a number of events have been held in the past several years relating to manure management and, more broadly, environmental management of livestock operations.

   - A composting workshop was held in conjunction with the Composting Council of Canada and the Saskatchewan Waste Reduction Council in Saskatoon in the fall of 1998. The objectives of the workshop were to: 1) provide livestock producers with up-to-date expert information on composting as a treatment option for various types of livestock manures; and 2) provide a forum for discussion of composting as a manure management treatment option in Saskatchewan.
   - The first Tri-Provincial (Manitoba, Saskatchewan, and Alberta) Manure Management Conference was held in the summer of 1999. The primary objective of the conference was to provide a forum for stakeholders to exchange information on sustainable manure management practices.
   - A Water Quality and Manure Management Workshop was hosted in 1999 by Saskatchewan Agriculture and Food in conjunction with Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration (AAFC-PFRA). The objective of the workshop was to provide extension agrologists with information on water quality and manure management.
   - In the summers of 2000 and 2001 Manure Management Field Tours were coordinated by Saskatchewan Agriculture and Food in cooperation with the Prairie Agriculture Research Institute and the University of Saskatchewan. In 2000, a one-day field tour was organized and in 2001 four half-day field tours were hosted.
   - In 2002, the second Tri-Provincial Manure Management Conference was held in Saskatoon. The objective of the conference was to promote manure management stewardship by providing principles, practices and planning tools for effective manure management for producers and agrologists.
   - In February 2003 Saskatchewan Agriculture and Food cooperated with the Saskatchewan Watershed Authority on a one-day workshop for cattle producers dealing with water quality. Saskatchewan Agriculture and Food provided information on manure management at this forum.
   - In the summer of 2003, a one-day manure management tour was hosted by Saskatchewan Agriculture and Food.

- In 2004, a one-day Manure Management Workshop was held in Saskatoon to discuss manure storage, manure treatment, manure odour, and manure application and use. This workshop primarily focused on the current state of knowledge in the Saskatchewan research community and also provided some information on new technologies for manure treatment from Saskatchewan and Manitoba. In addition the workshop was used to help identify and prioritize research gaps. The information compiled on research gaps was then provided to provincial funding agencies.
- In the fall of 2004, Saskatchewan Agriculture and Food, Saskatchewan Environment, and the Saskatchewan Waste Reduction Council, along with a number of provincial and federal agencies, hosted "Composting Matters!", a two-day conference on organics recycling and composting in Brandon, Manitoba.
- In July 2005, a presentation on sustainable manure management was given at the Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration's (AAFC-PFRA) Field Day.
- The third Tri-Provincial Manure Management Conference, entitled "Growing the Livestock Industry" and sponsored by Saskatchewan Agriculture and Food, was held in Saskatoon in 2005. The two-day conference included workshops, presentations and tours on manure management topics such as: "The Kyoto Accord: what does it mean for the producer?"; nutrient management; stewardship and water protection; and environmental management systems. The conference also included the option of a manure treatment technologies tour, a composting workshop or a manure management workshop highlighting the MARC (Manure Application Rate Calculator) software.
- In March 2006 a sustainable manure management presentation was given at the Sustainable Irrigation For The Prairies Workshop: Irrigation and the Environment - Challenges and Opportunities.

Table 21. Manure management workshops.

Year and event	Number of Participants
1998 - Composting Workshop	75
1999 - Tri-Provincial Manure Management Conference	305
2000 - Manure Management Field Tours	110
2001 - Manure Management Field Tours	10 – 30 /tour
2002 - Tri-Provincial Manure Management Conference	100
2003 – Water Quality Workshop	60
2003 – One-day Manure Management Tour	35
2004 – Composting Matters Conference in Brandon, MB	75
2004 – Tri-Provincial Manure Management Conference	225
2004 – Composting Conference in Saskatoon	50
2005 – PFRA's Field Day	15
2005 – Tri-Provincial Manure Management Conference	200
2006 – Sustainable Irrigation for the Prairies Workshop	80

5) *The "Living by Water" Workshops*. "Living by Water" Workshops have been delivered by Nature Saskatchewan to Saskatchewan residents since 1998. The purpose of the workshops is to educate the public about shoreline issues such as reducing erosion, the benefits of riparian buffers, and how these practices can improve water quality and provide wildlife habitat. In 2005 there were five workshops led by a Nature Saskatchewan facilitator. Participation numbers are not currently available.

   In the summer of 2005, the Saskatchewan Watershed Authority's Lake Stewardship Program adopted the "Living by Water" Program as a pilot project. To promote this pilot project presentations and home visits were done by the Lake Stewardship Program staff to four of the program's eleven lake stewardship groups. They included the Emma/Christopher Lakes Association, the Brightsand Lake Watershed Association, the Friends of Good Spirit Lake and the Last Mountain Lake Stewardship groups.

   There were three presentation topics: 1) Learning About Your Shoreline; 2) Shoreline Landscaping and Erosion; and 3) Agriculture, Our Cottage and Us. In total, seven presentations were given with approximately 100 people in attendance, and 30 home visits were conducted.

6) *The Zero Tillage Field Day*. The Zero Tillage Field Day has been managed by the Indian Head Agricultural Research Foundation since 1996. Field days consist of demonstration and research plot tours and presentations. Approximately 150-300 producers from North America attend each year.

Indicator		
Number of Stewardship Workshops	-	Number of stewardship workshops per watershed

Data Source: Locations of stewardship workshops delivered by the Saskatchewan Watershed Authority are from the Authority's Landowner Information Database. Information about the Environmental Farm Planning Workshops was provided by the Provincial Council of Agriculture Development and Diversification Boards for Saskatchewan Inc. (PCAB). Saskatchewan Soil Conservation Association information was provided by Juanita Polegi (Pers. Comm.). Information about the manure management workshops was provided by Karen Bolton (Pers. Comm.).

Data Discussion: The intention of this indicator is to include and map all of the stewardship workshops by watershed. Through the cooperation and collaboration of various organizations, we are currently in the process of obtaining data on additional workshops to be included in this indicator.

Agricultural Beneficial Management Practices Indicator

The issue

Agricultural Beneficial Management Practices (BMPs) are management practices designed to minimize the impacts and risks of agricultural land use on natural resources.

Agricultural Beneficial Management Practices Indicator in Saskatchewan

According to analysis done by Saskatchewan Agriculture and Food on Census of Agriculture data, between 1996 and 2001 there was an 86% increase in pre-seeding zero tillage. Other Saskatchewan soil conservation practices that have increased among farms reporting between 1996 and 2001 include winter crop cover (93%) and permanent grass cover (14%). Some of the Saskatchewan soil conservation practices that have decreased among farms reporting between 1996 and 2001 include crop rotation (-15%), grassed waterways (-7.6%), strip cropping (-33%), contour cultivation (-47%) and windbreaks and shelterbelts (-18%) (Saskatchewan Agriculture and Food 2002).

Between 1991 and 1996, the area of agricultural land under zero tillage management increased from 1,335,463 to 2,954,205 hectares, or to 22% of the total seeded land area in the province. The area under minimum or reduced tillage management increased from 3,358,891 to 4,411,074 hectares, or to 33% of the seeded area (Wall et al. 1998).

There are a number of programs in Saskatchewan that are promoting agriculture Beneficial Management Practices, including:

- The Saskatchewan Soil Conservation Association (SSCA). The SSCA is a non-profit, producer-based organization dedicated to the promotion of soil conservation in Saskatchewan. The SSCA provides producers with information and networks on soil conservation through activities such as newsletters, annual conferences, and extension materials.
- The Saskatchewan Agriculture Applied Research Management Program. Established in 1998 in cooperation with the Saskatchewan Soil Conservation Association, Agriculture and Agri-Food Canada and Saskatchewan Agriculture and Food, the program was initiated to promote precision farming through the development of demonstration projects.
- The Prairie Stewardship Program. With technical and administrative assistance provided by the Saskatchewan Watershed Authority, the program has promoted agricultural Beneficial Management Practices through the establishment of 278 riparian management demonstration projects. The demonstration projects include sites designed for riparian grazing management, perennial forage establishment, and corral/wintering site modification.

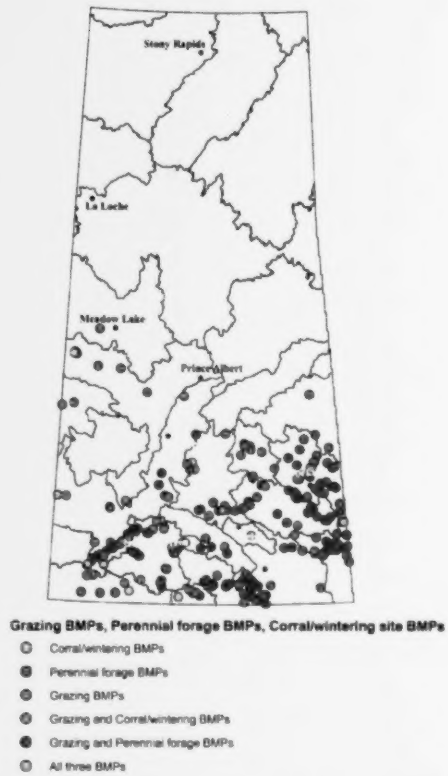

Figure 69. Riparian management Beneficial Management Practices.

- The Canada-Saskatchewan Farm Stewardship Program (CSFSP). The CSFSP was established in 2001 under the Agricultural Policy Framework (APF). The objective of the program is for producers to reduce some of the risks associated with agricultural land use practices by adopting Beneficial Management Practices. With the help of an advisor assisting with the on-farm plan, producers are encouraged to complete an Environmental Farm Plan. In the Environmental Farm Plan, producers identify the environmental risks associated with their current land use practices and the eligible BMPs that would help to reduce these environmental risks. Once their Environmental Farm Plans are completed, producers can apply for financial assistance to incorporate the identified BMPs. The program will pay between 30% and 50% of the eligible costs of implementing their plans, up to a maximum dollar amount. The program began in Saskatchewan on March 31, 2005 and will receive applications for funding until March 31, 2008.

Eligible Beneficial Management Practices under the Canada-Saskatchewan Farm Stewardship Program include:

- Improved Manure Storage and Handling
- Manure Treatment
- Manure Land Application
- In - Barn Improvements
- Runoff Control
- Enhancing Wildlife Habitat and Biodiversity
- Wintering Site Management
- Product and Waste Management
- Water Well Management
- Riparian Area Management
- Erosion Control Structures (Riparian)
- Erosion Control Structures (Non-Riparian)
- Land Management for Soils at Risk
- Improved Cropping Systems
- Cover Crops
- Relocation of Livestock Confinement and Horticultural Facilities
- Improved Pest Management
- Nutrient Recovery from Waste Water
- Irrigation Management
- Shelterbelt Establishment
- Invasive Alien Plant Species Control
- Species at Risk
- Preventing Wildlife Damage
- Nutrient Management Planning
- Integrated Pest Management Planning
- Grazing Management Planning
- Soil Erosion Control Planning
- Biodiversity Enhancement Planning
- Irrigation Management Planning
- Riparian Health Assessment

Of the 30 main categories of BMPs listed above, approximately 80% of the projects adopted fall into one of the following five categories: improved cropping systems, riparian area management, wintering site management, land management for soils at risk, and product and waste management (Agriculture and Agri-Food Canada 2006).

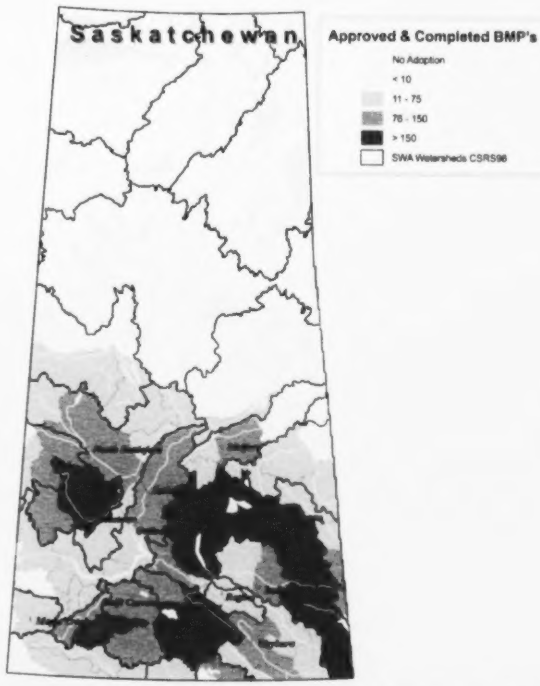

Figure 70. Adoption of BMPs by sub-watershed between 2005 and December 31, 2006. The 29 watershed boundaries are outlined in black; the sub-watershed boundaries are indicated by green boundary lines.

In 2002, a literature review focusing on appropriate agricultural Best Management Practices for protecting water quality in the Canadian prairies was conducted (Hilliard et al. 2002). The review identified the costs and benefits of Beneficial Management Practices appropriate for the Canadian prairie provinces.

Watershed and Land Use Planning Indicator

The issue

Integrated resource management is a process of managing both the environment and the land use activities to achieve sustainable development. The purpose of integrated resource management is to account for all land use interests (including environmental, economic, social, and cultural interests) in the planning process.

Watershed and Land Use Planning Indicator in Saskatchewan

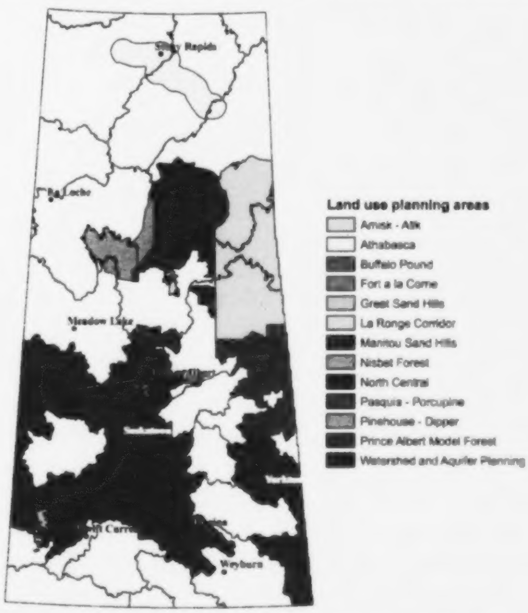

Figure 71. Watershed and land use planning initiatives in Saskatchewan.

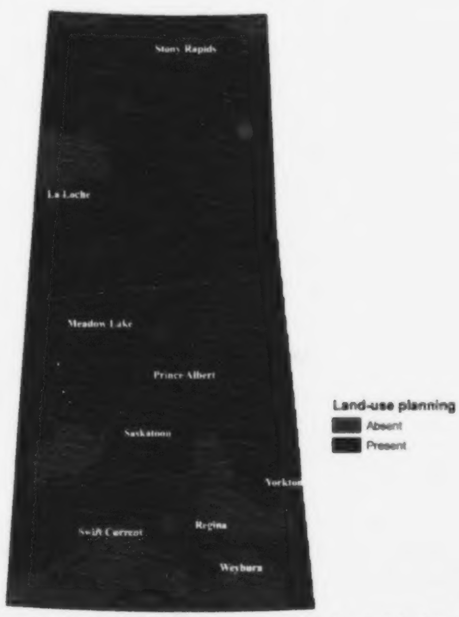

Figure 72. Watershed and land use planning initiatives in Saskatchewan by watershed.

Seventeen of Saskatchewan's watersheds are currently involved in one of the two main watershed and land use planning initiatives in Saskatchewan. The two main watershed and land use planning initiatives in Saskatchewan are:

- The Saskatchewan Watershed Authority's Watershed and Aquifer Planning, which was initiated in 2002 to achieve its mandate of protecting and maintaining sustainable source water quantity and quality. The planning process is a multi-stepped process, coordinated by the Authority's planners, designed to identify and integrate existing land use interests (including environmental, economic, social, and cultural interests). The purpose of the planning process is to develop a watershed and aquifer source water protection plan for land and resource management in the planning area. Steps in the planning process include:
  - the establishment of a watershed advisory committee(s) made up of stakeholders such as residents, producers, land managers, industry, municipalities, and individuals in the natural resource field;
  - the establishment of a technical committee made up experts in the fields of agriculture, biology, geology, hydrology and engineering;
  - the development of a background report to improve the public's understanding of the planning watershed or aquifer and the factors that impact the health of the watershed or aquifer;
  - the development of the source water protection plan for the planning watershed of interest;
  - the implementation of the source water protection plan; and
  - the monitoring and assessment of the activities.

  Currently, watershed and aquifer planning is directly active in eight watersheds (the North Saskatchewan River, Battle River, South Saskatchewan River, Upper Qu'Appelle River, Wascana Creek, Moose Jaw River, Upper Assiniboine River, Lower Souris River Watersheds) and for the aquifers in the Yorkton area (Saskatchewan Watershed Authority 2002).

Eligible Beneficial Management Practices under the Canada-Saskatchewan Farm Stewardship Program include:

- Improved Manure Storage and Handling
- Manure Treatment
- Manure Land Application
- In-Barn Improvements
- Runoff Control
- Enhancing Wildlife Habitat and Biodiversity
- Wintering Site Management
- Product and Waste Management
- Water Well Management
- Riparian Area Management
- Erosion Control Structures: Riparian
- Erosion Control Structures: Non-Riparian
- Land Management for Soils at Risk
- Improved Cropping Systems
- Cover Crops
- Relocation of Livestock Confinement and Horticultural Facilities
- Improved Pest Management
- Nutrient Recovery from Waste Water
- Irrigation Management
- Shelterbelt Establishment
- Invasive Alien Plant Species Control
- Species at Risk
- Preventing Wildlife Damage
- Nutrient Management Planning
- Integrated Pest Management Planning
- Grazing Management Planning
- Soil Erosion Control Planning
- Biodiversity Enhancement Planning
- Irrigation Management Planning
- Riparian Health Assessment

Of the 30 main categories of BMPs listed above, approximately [illegible] of the projects adopted fall into one of the following five categories: improved cropping systems, riparian area management, wintering site management, land management for soils at risk, and product and waste management (Agriculture and Agri-Food Canada 2006).

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In 2005, a literature review focusing on appropriate agricultural Best Management Practices for protecting water quality in the Canadian prairies was conducted (Hilliard et al. 2005). The review identifies the costs and benefits of Beneficial Management Practices appropriate for the Canadian prairie provinces.

Watershed and Land Use Planning Indicator

The issue

Integrated resource management is a process of managing both the environment and the land use activities to achieve sustainable development. The purpose of integrated resource management is to account for all land use interests (including environmental, economic, social, and cultural interests) in the planning process.

Watershed and Land Use Planning Indicator in Saskatchewan

Figure 71. Watershed and land use planning initiatives in Saskatchewan.

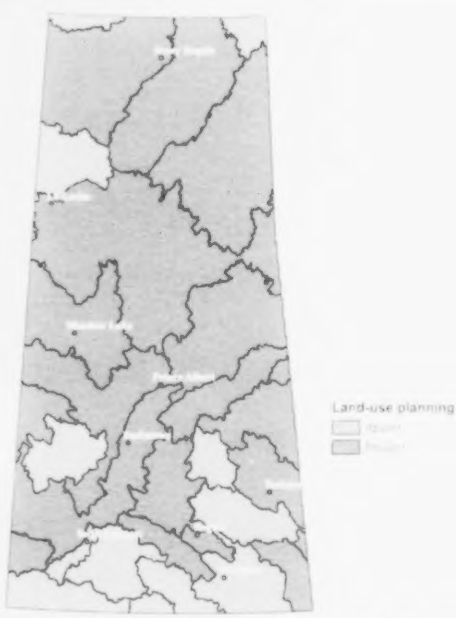


Figure 72. Watershed and land use planning initiatives in Saskatchewan by watershed.

Seventeen of Saskatchewan's watersheds are currently involved in one of the two main watershed and land use planning initiatives in Saskatchewan. The two main watershed and land use planning initiatives in Saskatchewan are:

- The Saskatchewan Watershed Authority's Watershed and Aquifer Planning, which was initiated in 2003 to achieve its mandate of protecting and maintaining sustainable source water quantity and quality. The planning process is a multi-stepped process, coordinated by the Authority's planners, designed to identify and integrate existing land use interests (including environmental, economic, social, and cultural interests). The purpose of the planning process is to develop a watershed and aquifer source water protection plan for land and resource management in the planning area. Steps in the planning process include:
  - the establishment of a watershed advisory committee(s) made up of stakeholders (such as residents, producers, local municipalities, industry, interest groups) and individuals in the natural resource field;
  - the establishment of a technical committee made up of experts in the fields of agriculture, biology, geology, hydrology and engineering;
  - the development of a background report to increase the public's understanding of the watershed, watershed or aquifer and the factors that impact the health of the watershed or aquifer;
  - the development of the source water protection plan for the planning watershed or aquifer;
  - the implementation of the source water protection plan; and
  - the monitoring and assessment of the activities.

  Currently, watershed and aquifer planning is directly active in eight watersheds: the North Saskatchewan River, Battle River, South Saskatchewan River, Upper Qu'Appelle River, Swift Current Creek, Moose Jaw River, Upper Assiniboine River, Lower Souris River Watersheds, and for the aquifers of [illegible] Yorkton and [illegible] (Saskatchewan Watershed Authority, 2006).

- Saskatchewan Environment's land use planning on Crown lands. The purpose of the land use planning process is to identify and integrate existing land use interests (including, environmental, economic, social, and cultural interests), resolve conflict and develop land and resource management plans for Crown lands in the planning area. Steps in the land use planning process include:
  - plan initiation;
  - information and issue gathering;
  - meetings;
  - draft plan preparation;
  - draft plan review;
  - plan revision and approval; and
  - plan implementation.

  Through this planning process two documents are produced: a background document that provides information about the planning area and the land use planning process, and a management plan.

  At present, Saskatchewan Environment has completed six integrated forest land use plans, five integrated land use plans, and developed a model forest for integrated resource management planning and research. These include:
  - the Amisk-Atik Integrated Forest Land Use Plan;
  - the Athabasca Land Use Plan;
  - the Buffalo Pound Lake Land Use and Resource Management Plan;
  - the Fort a la Corne Integrated Forest Land Use Plan;
  - the Great Sand Hills Land Use Strategy;
  - the La Ronge Integrated Land Use Management Plan;
  - the Manitou Sand Hills Integrated Land Use Plan;
  - the Nisbet Provincial Forest Integrated Forest Land Use Plan;
  - the North-Central Integrated Forest Land Use Plan;
  - the Pasquia/Porcupine Integrated Forest Land Use Plan;
  - the Pinehouse – Dipper Integrated Forest Land Use Plan; and
  - the Prince Albert Model Forest. The Prince Albert Model Forest was formed in 1992 through partnerships with First Nations and federal and provincial resource management agencies (Saskatchewan Environment 2006i).

Indicator		
Watershed and land use planning	**=**	**Watershed or land use planning has occurred within the watershed**

Rating Scheme

Number of Conservation Stewards
Absent/Gap = No watershed or land use planning has occurred in the watershed.
Present = Watershed or land use planning has occurred in the watershed.

Data Source: The location and information on land-use planning in Saskatchewan was obtained from the respective government departments involved in the monitoring.

Water Quality Monitoring and Management Indicator

The issue

Water quality monitoring and management programs in Saskatchewan exist for a number of purposes. Some programs were established to conduct long-term monitoring at permanent stations, while others are short-term and have been developed to address a specific question. The objectives and purposes of the water quality monitoring programs determine what chemical, physical and/or biological parameters are collected and assessed.

Water Quality Monitoring and Management Indicator in Saskatchewan

Figure 73. Spatial distribution of water quality monitoring stations.

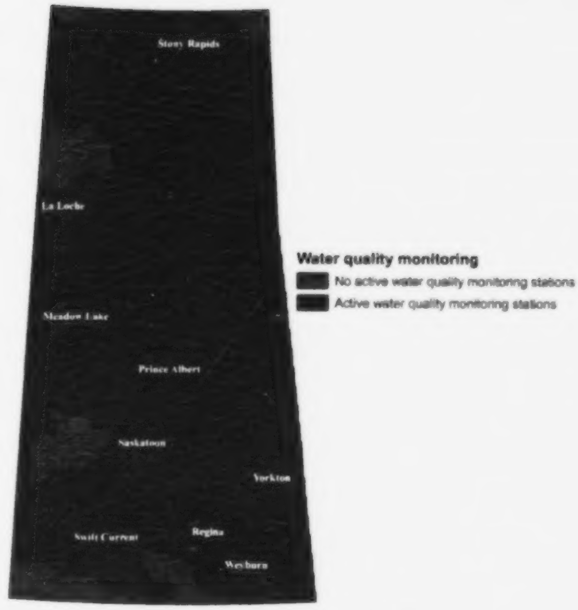


Figure 74. Water quality monitoring by watershed.

Water quality sampling, conducted by government-run water quality monitoring programs, occurs in 23 of Saskatchewan's 29 watersheds.

Some of the ongoing water quality monitoring programs initiated in Saskatchewan by the federal and provincial governments include:

Surface Water Quality Monitoring Programs

1) Saskatchewan Environment's Surface Water Monitoring Program. The purpose of the Surface Water Quality Monitoring Program is to: determine the water quality of select watercourses; quantify the loading of pollutants from point sources; assist in the establishment of total maximum daily loading of pollutants; estimate the natural background conditions of the watercourses; and allow temporal and spatial comparisons of water quality (Saskatchewan Environment 2005c).

   In 2005, as part of Saskatchewan Environment's Surface Water Monitoring Program, 22 primary monitoring stations were actively sampled at least eight times. Prior to 1997, water quality samples were collected at 18 primary stations and a number of secondary locations. Between 1997 and 2005, limited water quality monitoring was conducted at the primary sites. As of 2005, this program is monitoring eleven of Saskatchewan's 29 watersheds.

The water quality parameters measured include: nutrients; major ions; bacteriological; general water quality [pH, dissolved oxygen (DO), temperature]; organics; chlorophyll a; suspended solids; and select pesticides and trace metals.

2) Prairie Provinces Water Board's Monitoring Program. The purpose of Prairie Provinces Water Board's (PPWB) water quality monitoring is to ensure that water quality at inter-provincial boundaries is maintained at acceptable levels.

   The Prairie Provinces Water Board monitors the water quality along the 11 major eastward flowing rivers that cross inter-provincial boundaries between the three Canadian prairie provinces. The monitoring is conducted by Environment Canada at 12 long-term water quality monitoring sites located along the Alberta-Saskatchewan and Saskatchewan-Manitoba borders. Eight of the sites are monitored monthly, one site is monitored once every two months, and three sites are monitored quarterly. Water samples are collected and analyzed for a range of parameters and compared with the PPWB's site-specific water quality objectives listed in Schedule E of the Master Agreement. Water quality parameters measured include: nutrients; major ions, bacteriological; general water quality [pH, dissolved oxygen (DO), temperature]; organics; chlorophyll a; suspended solids; and select pesticides and trace metals.

3) The Saskatchewan Watershed Authority's River and Lake Water Quality Monitoring. The Saskatchewan Watershed Authority conducts water quality monitoring at thirteen locations on rivers and lakes in Saskatchewan. Water quality monitoring is conducted at least six times a year at the following sites: the Qu'Appelle River at Edenwold; Pasqua Lake; Echo Lake; Mission Lake; Katepwa Lake; Crooked Lake; and Round Lake. Seasonal and compliance water quality monitoring is conducted on: the Pipestone River; the Moose Jaw River; the Souris River; Rough Bark Creek; Moose Mountain Creek; and the Rafferty and Alameda Reservoirs. The water quality parameters measured are the same as Saskatchewan Environment's Surface Water Monitoring Program's parameters. These include: nutrients; major ions; bacteriological; general water quality [pH, dissolved oxygen (DO), temperature]; organics; chlorophyll a; suspended solids; and select pesticides and trace metals.

   In addition to discrete water quality monitoring, the Saskatchewan Watershed Authority is also involved in continuous, real-time water quality monitoring of the Qu'Appelle River at the junction of the Moose Jaw River. The continuous monitoring is conducted using YSI data sondes. Water quality parameters measured include: dissolved oxygen; conductivity; temperature; pH; Redox; turbidity; and chlorophyll a. The purpose of the continuous monitoring program is to compare data from continuously gathered water samples with discrete samples collected at specific time intervals (e.g. monthly in the summer) to evaluate the effectiveness/representativeness of the current sampling program and to develop calibration curves for other water quality parameters. Continuous data will be used to develop in-stream flow requirements, monitor water quality, determine the efficacy of wastewater treatment, allow the construction of frequency distribution curves to determine the percentage of time that concentrations exceed Provincial Surface Water Quality Objectives, and they will be a major tool for assisting with the development of mixing zone objectives.

4) The Saskatchewan Watershed Authority's Lake Stewardship Monitoring Program. The purpose of the Lake Stewardship Program is to: develop partnerships between stewardship groups and other agencies to promote, protect, and preserve water quality and aquatic life; develop an understanding of lake water quality that is shared with the public; and use water quality data to improve decision-making within the watershed.

   The Lake Stewardship Program currently monitors the water quality at baseline and shoreline locations on thirteen Saskatchewan lakes. Baseline stations are typically located at the point of maximum depth or near the centre of the lake. Shoreline stations are site-specific depending on local water quality concerns. Water samples are collected six times a year: four times during the summer and twice during the winter. The water quality parameters measured for shoreline sites include: nutrients; general water quality [pH, dissolved oxygen (DO), temperature]; suspended solids and chlorophyll *a*. The water quality parameters for baseline sites include: nutrients; major ions; bacteriological; general water quality [pH, dissolved oxygen (DO), temperature]; organics; chlorophyll *a*; suspended solids; and select pesticides and trace metals.

In 2006, the Saskatchewan Watershed Authority's Lake Stewardship Program included eleven stewardship groups:

i) Stewards of Jackfish and Murray Lakes
ii) Friends of Good Spirit Lake
iii) Big Shell Lake Watershed Stewardship Association
iv) Brightsand Lake Watershed Association
v) Kelvington Area Round Lake Environmental Stewardship
vi) Pipestone Watershed Stewardship Committee
vii) Lac Pelletier Stewards
viii) Last Mountain Lake Stewardship Groups
ix) Turtle Lake Watershed Inc.
x) Emma/Christopher Lakes Association
xi) Anglin Lake Cottage Owners Association

Groundwater Quality Monitoring Programs

5) Saskatchewan Watershed Authority's Rural Water Quality Advisory Program. The purpose of the Rural Water Quality Advisory Program is to: address concerns over the safety of rural water compared with water from urban centers; address the lack of awareness of potential health and aesthetic issues; improve quality of life; and develop a provincial water quality database of rural water quality.

   The Rural Water Quality Advisory Program (RWQAP) has been operating provincially since November 1997. The program provides a full consultative service to anyone relying on a private water supply. As of December 2005, the RWQAP had sampled the private water supply, wells and dugouts of over 3,000 clients. Approximately 90% of the samples collected under the RWQAP were groundwater and 10% of the samples were from private surface water supplies. Water quality parameters measured include: nitrate; major ions; bacteriological; general water quality [pH, dissolved oxygen (DO), temperature]; organics; suspended solids, and trace metals.

Water Quality Monitoring Programs to Address Potential Environmental Impacts

6) Environment Canada's Environmental Effects Monitoring Program. The purpose of the Environmental Effects Monitoring Program is to determine the environmental impact and degradation associated with the release of effluent from pulp and paper mills and metal mines.

   The Environmental Effects Monitoring Program has been operating since June 2002. Within the program water, sediment, aquatic benthic invertebrates, fish population and demographic data and fish tissue are sampled. Water quality parameters measured include: nutrients (nitrate); general water quality (pH, DO, electrical conductivity); major ions; select trace metals; and the radionuclide ^{226}Ra.

7) Saskatchewan Agriculture and Food and Saskatchewan Environment's Intensive Livestock Operations' Monitoring Program. The purpose of the program was to establish a baseline of the surface water quality of these watercourses. Based on the results from the data collected from these monitoring stations between 1998 and 2003, no trend in surface water quality was observed in watercourses adjacent to areas where manure was spread. To ensure water quality is not impacted by intensive livestock operations (ILOs), additional ongoing water quality sampling and analysis will continue (Low 2003).

   In 1998, Saskatchewan Agriculture and Food and Saskatchewan Environment initiated this monitoring program to assess potential impacts from intensive livestock operations on the environment. The program has focused on eight regions in Saskatchewan where intensive hog operations were spreading manure near watercourses. Sampling sites included: 1) Dellwood Brook/Burr C&D ditch (Upper Qu'Appelle River Watershed); 2) Lanigan Creek (Upper Qu'Appelle River Watershed); 3) Duck Creek/Meadowbank Creek (Lake Winnipegosis Watershed); and 4) Leather River/Sweetwater Creek (Carrot River Watershed).

   Surface water quality data from adjacent watercourses were collected annually during spring runoff. Water quality parameters measured include: nutrients; major ions; bacteriological; general water quality [pH, dissolved oxygen (DO), temperature]; organics; chlorophyll *a*; suspended solids; and select pesticides and trace metals.

8) Saskatchewan Environment's Cumulative Effects Monitoring Program. The purpose of the Cumulative Effects Monitoring (CEM) Program is to: assess the impact of uranium mining activities on the environment; inform the northern communities in the study area about the state of their environment; and ensure that the health of the community is maintained.

   The program was initiated in 1994 in response to the joint Federal-Provincial Panel on Uranium Development in Northern Saskatchewan. The program collects water, sediment, aquatic macrophyte, and fish tissue samples from class effects and regional effects sampling stations once a year on a three-year rotation.

Class effects sampling stations are in close proximity to a discharge location and are used to assess cumulative effects of the effluent from more than one uranium mine that may result in spatial and/or temporal overlap. Class sampling stations are located in three areas of northern Saskatchewan: the west side of Wollaston Lake; the Cluff Lake area; and the Key Lake/McArthur River area.

Regional effects sampling stations are located far from the mine sites and are used to measure the long-range transport of contaminants over an extended period of time. Numerous regional stations, also known as Ecosystem Health stations, have been established throughout northern Saskatchewan. The water quality parameters measured include: nutrients; major ions, bacteriological; general water quality [pH, dissolved oxygen (DO), temperature]; organics; chlorophyll *a*; suspended solids; and select trace metals and radionuclides (^{210}Pb; ^{210}Po; ^{226}Ra; 230^{Th} and U) (Canada North Environmental Services 2002).

Indicator		
Water Quality Monitoring and Management	=	Water quality monitoring is actively occurring within the watershed.

Rating Scheme

Water Quality Monitoring and Management
Absent/Gap – No water quality monitoring is actively occurring within the watershed.
Present – Water quality monitoring is actively occurring within the watershed.

Data Source: The locations and information on water quantity monitoring programs were obtained from the respective government departments involved in the water quality monitoring programs.

Water Quantity Monitoring and Management Indicator

The issue

Programs assessing water quantity exist in Saskatchewan for a number of reasons. Some programs assess water quantity as part of international or inter-provincial agreements, while others are to assess water quantity for provincial allocation and supply purposes.

Water Quantity Monitoring and Management Indicator in Saskatchewan

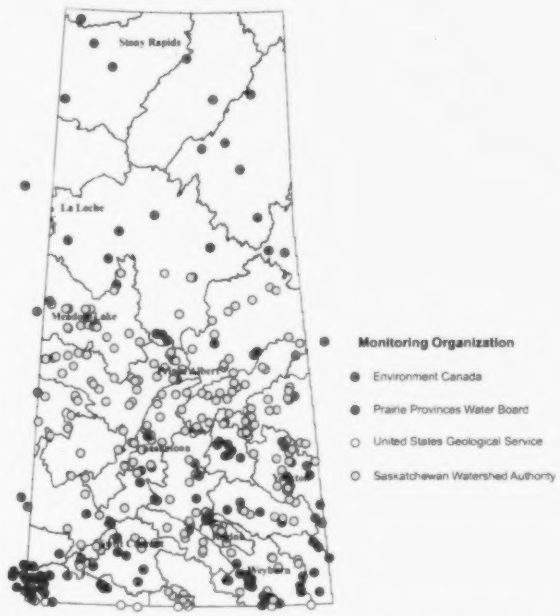


Figure 75. Spatial distribution of hydrometric station locations by monitoring organization.

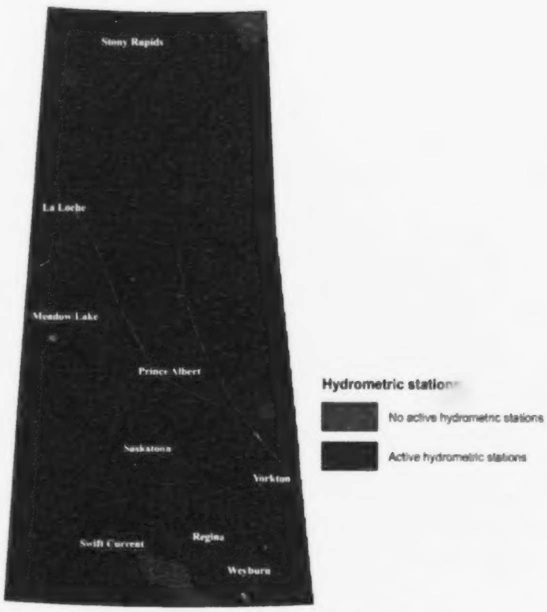


Figure 76. Water quantity monitoring by watershed.

Water quantity monitoring programs are active in 27 of the 29 watersheds in Saskatchewan.

Ongoing water quantity monitoring programs initiated within Saskatchewan by federal and provincial governments include:

1) Environment Canada's Water Survey of Canada. The Water Survey of Canada is a cooperative initiative introduced in 1908 by the federal and provincial governments. The purpose of the Water Survey of Canada is to collect, analyze and publish information on water resources in Canada. Data are primarily collected using hydrometric stations. In Saskatchewan there is a network of 323 active hydrometric stations, of which 142 are monitored by Environment Canada, eight are monitored by the United States Geological Service as part of the transboundary agreement, 14 are monitored by the Prairie Provinces Water Board as part of the Master Agreement on Apportionment, and 159 are monitored by the Saskatchewan Watershed Authority. The Authority operates the stations as a contributing partner to the national database. Each hydrometric station records water level data on a continuous basis, either using a mechanical (analogue) recorder or an electronic recorder, or data logger. Data are used to calculate the rate of flow, or discharge, of a river or the water level of a lake.
2) The Prairie Provinces Water Board's Monitoring Program. The Prairie Provinces Water Board monitors the water quantity at 14 locations along the 11 major eastward flowing rivers that cross inter-provincial boundaries between the three Canadian prairie provinces. The purpose of this Water Quantity Monitoring Program is to ensure that the waters from eastward flowing rivers in the prairie provinces are shared equitably.

   In 1948, the provincial governments of Alberta, Saskatchewan, Manitoba and the federal government all signed the Prairie Provinces Water Board Agreement. The purpose of the agreement was to resolve inter-provincial conflicts between upstream uses and downstream needs. In 1969, the Master Agreement on Apportionment was signed by the same governments. The Master Agreement on Apportionment states that "Alberta and Saskatchewan may each take up to one half of the natural flow of water originating within its boundaries and one half of the flow entering the province. The remainder is left to flow into Manitoba" (Prairie Provinces Water Board).
3) The Saskatchewan Watershed Authority's Provincial Streamflow Forecast. Using hydrometric data, the Saskatchewan Watershed Authority River Forecast Centre prepares monthly Provincial Streamflow Forecasts for Saskatchewan. These forecasts describe the current stream flow and water levels in the province and provide forecasts of expected flow conditions and lake levels (http://www.swa.ca/WaterManagement/ProvincialForecast.asp).
4) The Saskatchewan Watershed Authority's Observation Well Network. The Observation Well Network was established in 1964 by the Saskatchewan Research Council to monitor groundwater in Saskatchewan. The purpose of the network is to provide long-term information on the impacts of groundwater withdrawals on the water levels of aquifers throughout Saskatchewan.

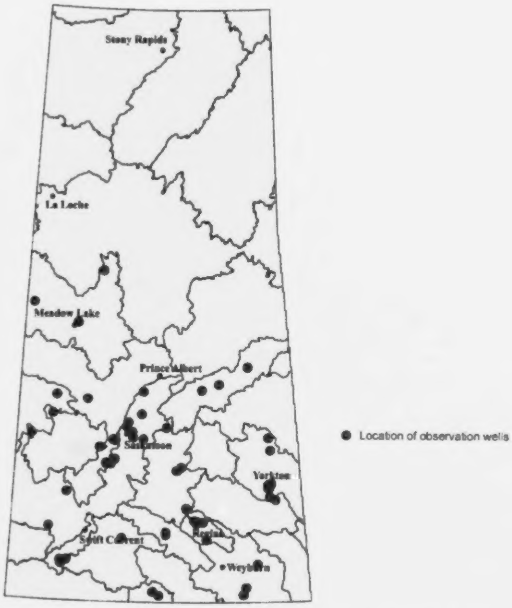


Figure 77. Spatial distribution of the Observation Well Network.

Figure 77 illustrates the spatial distribution of the Observation Well Network. The range of fluctuations in water levels is still not well understood, as less than 40 years of monitoring information has been collected. In 1988, the Saskatchewan Watershed Authority initiated a second observation network to monitor water levels in areas of high development, such as the Regina and Yorkton area aquifer systems.

Water level measurements from observation wells located throughout Saskatchewan are in digital format. These water level measurements are illustrated as hydrographs. At present, there are 72 observation wells located throughout Saskatchewan. Of the 72 wells, 54 were previously monitored by the Saskatchewan Research Council and 18 by the Saskatchewan Watershed Authority. As of April 1, 2005 the Saskatchewan Watershed Authority assumed responsibility for the observation wells operated by SRC. To date, the Authority is responsible for the 72 active observation wells located throughout Saskatchewan. These hydrographs are updated bi-annually. A brief description and information for each observation well can be obtained through the Saskatchewan Watershed Authority's website (http://www.swa.ca/WaterManagement/Ground water.asp?type=ObservationWells).

General information regarding groundwater and water wells is available to the public. Potential water bearing zones are interpreted using past drilling information, water chemistry, and the geology and groundwater resource maps. The information provides general guidance to the public for the water supply potential at a given location.

In addition to monitoring programs, there have been numerous investigations and reports written on water quantity in Saskatchewan. Some of these investigations and reports include:

- The Saskatchewan Rural Water Mapping Initiative, initiated by Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration (AAFC-PFRA);
- *Annual Unit Runoff on the Canadian Prairies* (Bell 1994);
- *The Distribution and Variability of Runoff in Alberta, Saskatchewan and Manitoba* (Durrant and Salway 1964);
- *Report on Median Annual Unit Runoff for the Prairie Provinces* (Mowchenko 1978);
- *Magnitude and Frequency of Peak Flows and Flow Volumes in Saskatchewan* (Aaston 1986); and
- Numerous reports produced by the Prairie Provinces Water Board related to stream flow, water use and deficiencies in Canada's three Prairie provinces (http://www.mb.ec.gc.ca/water/fa01/fa01s56.en.html).

Indicator		
Water Quantity Monitoring and Management	=	Water quantity monitoring is actively occurring within the watershed.

Rating Scheme

Water Quantity Monitoring and Management
Absent/Gap = No active hydrometric stations exist in the watershed.
Present = At least one active hydrometric station exists in the watershed.

Data Source: The locations and information on water quantity monitoring programs were obtained from the respective government departments involved in the monitoring.

Protected Areas Indicator

The issue

The largest threat to biodiversity is loss of habitat. Protected areas are an important component in conserving Saskatchewan's biodiversity and natural resources. The purpose of protected areas are varied, and "range from the protection of natural habitats and associated flora and fauna, to the maintenance of environmental stability of the surrounding regions" (Convention on Biological Diversity n.d.).

Protected Areas Indicator in Saskatchewan

World leaders attended the 1992 Earth Summit in Rio de Janeiro, where they agreed upon a strategy for sustainable development. Canada was the first industrialized country to ratify the Convention on Biological Diversity, one of two binding agreements signed at the Earth Summit. Canada's Response to the Convention on Biological Diversity was the development of the Canadian Biodiversity Strategy, which was released publicly in 1995 (Biodiversity Convention Office 1995).

In 1998, in response to the Canadian Biodiversity Strategy, the Saskatchewan Biodiversity Interagency Steering Committee was established. The purpose of Saskatchewan's Biodiversity Interagency Steering Committee was to oversee the development of a biodiversity action plan for Saskatchewan.

In 1999, the Government of Saskatchewan released a progress report entitled *Conserving Saskatchewan's Biodiversity*. The report is a summary of Saskatchewan's existing and upcoming policies, plans and programs that support the Canadian Biodiversity Strategy. Each of Saskatchewan's initiatives are grouped into one of the Canadian Biodiversity Strategy's five goals, which are:

- to conserve biodiversity and use biological resources in a sustainable way;
- to improve our understanding of ecosystems and increase our resource management capability;
- to promote an understanding of the need to conserve biodiversity and use biological resources in a sustainable manner;
- to maintain or develop incentives and legislation that support conservation of biodiversity and the sustainable use of biological resources; and
- to work with other countries to conserve biodiversity, use biological resources in a sustainable manner and equitably share the benefits that arise from the utilization of genetic resources.

To further understand the status of biological resources in Saskatchewan, the Saskatchewan Research Council identified, categorized, and ranked the potential threats to biodiversity in Saskatchewan. The result was a review document entitled *Threats to Biodiversity in Saskatchewan* (1999). Results of this review document highlight habitat loss/alteration, fragmentation, and exotic species as the most prevalent threats to terrestrial biodiversity, and habitat loss/alteration, fragmentation, and pollution as the most prevalent threats to aquatic biodiversity.

Public consultation was an important component in the development of Saskatchewan's Biodiversity Action Plan. The first phase of public consultation on biodiversity was the preparation of the discussion paper entitled *Conserving Saskatchewan's Natural Environment: Framework for a Saskatchewan Biodiversity Action Plan* (Government of Saskatchewan 2000). Public consultation consisted of meetings with the public and various interest groups and a series of staff workshops with government department and agencies. The second phase of public consultation was through public feedback on the document entitled *Conserving Saskatchewan's Natural Environment: A Proposed Saskatchewan Biodiversity Action Plan* (Government of Saskatchewan 2002b).

In 2004, Saskatchewan's Biodiversity Interagency Steering Committee released *Caring for Natural Environments: A Biodiversity Action Plan for Saskatchewan's Future 2004-2009* (Government of Saskatchewan 2004a). The final action plan incorporated the feedback received from the first and second phase of public consultation, and included a revised vision for biodiversity conservation, six principles for an action plan, and highlighted the 15 priority objectives and associated actions that were grouped into the five goals of the Canadian Biodiversity Strategy. The focus of the action plan was to encourage all sectors of government to conserve biodiversity and promote the sustainable use of natural resources through an ecosystem-based management approach. Proposed governmental actions included the improvement of policies and programs, planning and management systems, and access to information. Included in Saskatchewan's Biodiversity Action Plan, the province is committed to achieving a target of 12% of the province being recognized as contributing to the Representative Areas Network in the province.

The Representative Areas Network Program was initiated in 1997 by Saskatchewan Environment. The purpose of the program is to conserve areas of land and water within Saskatchewan that are representative of a unique part of the province's 11 ecoregions.

Figure 78. Percent of watershed with protected areas that are part of Saskatchewan's Representative Areas Network: 2006.

All 29 watersheds have at least one protected area that is part of Saskatchewan's Representative Areas Network. Eight of the 29 watersheds have protected areas that comprise 12% or more of the watershed area. The remaining 21 watersheds have protected areas that cover less than 12% of their area.

$$\text{Percent of watershed with protected areas} = \frac{\text{Area of protected areas within a watershed (ha)}}{\text{Total watershed area (ha)}}$$

Rating Scheme

Less than target = Less than 12% of the watershed is covered by protected areas.

Met target = At least 12% of the watershed is covered by protected areas.

Data Source: Shapefiles used to create this indicator are from the Government of Saskatchewan's Representative Area Network Geodatabase.

Data Quality/Caveats: Protected areas that are part of Saskatchewan's Representative Areas Network (RAN) include: ecological reserves; protected areas; special management areas; provincial parks; national parks; parkland reserves; recreation sites; *Wildlife Habitat Protection Act* lands; national wildlife areas; wildlife refuges; provincial community pastures; migratory bird sanctuaries; the Prairie Farm Rehabilitation Administration's community pastures; provincial community pastures; Ducks Unlimited Canada land; and conservation easements. Although conservation easements are part of the Representative Areas Network they are only available as a point shapefile. Therefore, the area of land covered by conservation easements is currently not included in the Government of Saskatchewan's Representative Area Network Geodatabase or the indicator calculations used to develop Figure 78.

The Representative Areas Network Program was initiated in 1997 by Saskatchewan Environment. The purpose of the program is to conserve areas of land and water within Saskatchewan that are representative of a unique part of the province's 11 ecoregions.

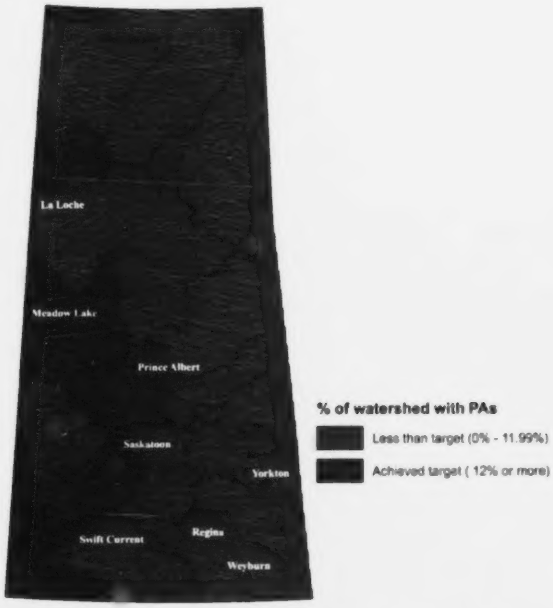


Figure 78. Percent of watershed with protected areas that are part of Saskatchewan's Representative Areas Network: 2006.

All 29 watersheds have at least one protected area that is part of Saskatchewan's Representative Areas Network. Eight of the 29 watersheds have protected areas that comprise 12% or more of the watershed area. The remaining 21 watersheds have protected areas that cover less than 12% of their area.

Indicator		
Percent of watershed with protected areas	=	Area of protected areas within a watershed (ha) / Total watershed area (ha)

Rating Scheme

Percent of Watershed with Protected Areas
Less than target – Less than 12% of the watershed is covered by protected areas.
Met target – At least 12% of the watershed is covered by protected areas.

Data Source: Shapefiles used to create this indicator are from the Government of Saskatchewan's Representative Area Network Geodatabase.

Data Quality/Caveats: Protected areas that are part of Saskatchewan's Representative Areas Network (RAN) include: ecological reserves; protected areas; special management areas; provincial parks; national parks; parkland reserves; recreation sites; *Wildlife Habitat Protection Act* lands; national wildlife areas; wildlife refuges; provincial community pastures; migratory bird sanctuaries; the Prairie Farm Rehabilitation Administration's community pastures; provincial community pastures; Ducks Unlimited Canada land; and conservation easements. Although conservation easements are part of the Representative Areas Network they are only available as a point shapefile. Therefore, the area of land covered by conservation easements is currently not included in the Government of Saskatchewan's Representative Area Network Geodatabase or the indicator calculations used to develop Figure 78.

Legislative Tools, Strategies, Policies, and Guidelines Indicator

The issue

Legislative tools are legally enforceable rules that have been established by federal, provincial and municipal governments to address and mitigate issues that are encountered due to human activity.

The primary federal and provincial legislation, strategies, policies and guidelines that have been developed to address issues such as those arising from the stressor indicator section are provided below.

Legislative Tools, Strategies, Policies, and Guidelines Indicator in Saskatchewan

Legislative Tools, Strategies, Policies, and Guidelines related to Human Settlement

The Planning and Development Act, 1983, is the primary legislation controlling community planning in Saskatchewan. This Act establishes both planning authorities and districts and their functions; outlines the purpose and content of development plans and zoning bylaws; describes the appointment and purpose of a Development Appeals Board; and the dedication of lands requirement by land owners.

The Cities Act regulates and provides legislative power to cities within Saskatchewan.

The Municipalities Act regulates and provides legislative power to rural municipalities, Towns, Villages and Resort Villages within Saskatchewan.

The Northern Municipalities Act regulates and provides legislative power to northern municipalities, settlements, Hamlets and Villages within Saskatchewan.

Legislative Tools, Strategies, Policies, and Guidelines related to Roads

The Planning and Development Act, 1983, is the primary legislation controlling community planning in Saskatchewan. This Act establishes both planning authorities and districts and their functions; outlines the purpose and content of development plans and zoning bylaws; describes the appointment and purpose of a Development Appeals Board; and the dedication of lands requirement by land owners.

The Highways and Transportation Act, 1997 and *Regulations*, regulated by Saskatchewan Highways and Transportation, deals with highways, public improvements, transportation and transportation systems.

Area Transportation Planning Committees were initiated by Saskatchewan Highways and Transportation to assist in the planning of transportation systems in Saskatchewan. The first committee was established in 1995. Committee members include representatives from rural and urban municipalities, Regional Economic Development Authorities, the Saskatchewan Urban Municipalities Association (SUMA), the Saskatchewan Association of Rural Municipalities (SARM), Saskatchewan Highways and Transportation, and other major stakeholder groups in the area (http://www.highways.gov.sk.ca/docs/programs_services/ATPC/Area_Trans_Comm.asp).

Legislative Tools, Strategies, Policies, and Guidelines related to Ground and Surface Water

The Conservation and Development Act and Regulations, administered by the Saskatchewan Watershed Authority, facilitates and explains the necessary procedures to establish conservation and development areas. Conservation and development areas allow for flood control, drainage, and multipurpose works to be constructed, operated and maintained for the benefit of agricultural lands and wildlife.

The Drainage Control Regulations, administered by the Saskatchewan Watershed Authority, establishes a permit system for the operation and construction of drainage projects.

The Ground Water Regulations, administered by the Saskatchewan Watershed Authority, controls exploration for and use of groundwater through the establishment of a permit system. The Regulations set out requirements that the owner and driller must comply with, including registering machinery, submitting drilling records, well disinfection and construction methods, test hole abandonment procedures, and licensing and use of groundwater.

The Reservoir Development Area Regulations, administered by the Saskatchewan Watershed Authority, describes the regulatory requirements to obtain a development permit for constructing, moving, or using a structure or land within a reservoir development area for the purpose of lake and shoreline development.

The Saskatchewan Watershed Authority Act, 2005, administered by the Saskatchewan Watershed Authority, established the Saskatchewan Watershed Authority in October 2002. The Act mandates that the Authority: manage and protect Saskatchewan's source water, watersheds and related lands; promote water conservation; regulate water development and water use; and promote research and conservation programs related to the aforementioned activities.

The Water Power Act, administered by the Saskatchewan Watershed Authority, provides regulations for the development of power plants for the purpose of commercial energy generation where energy is generated from flowing or falling water.

The Watershed Associations Act, administered by the Saskatchewan Watershed Authority, permits a Watershed Association to be formed by two or more agencies for the purpose of planning, operating, constructing, improving, and maintaining projects to protect or develop land and water resources at a watershed level.

The Prairie Farm Rehabilitation Act established the Prairie Farm Rehabilitation Administration (PFRA) in 1935. The act mandates that PFRA develop and deliver soil and water conservation and development programs.

The Saskatchewan Wetland Policy was developed in 1995 by a consortium of provincial agencies. This policy is implemented by provincial government departments and agencies, and led by the Saskatchewan Watershed Authority. The objective of the policy is to "promote the sustainable management of wetlands on public and private lands" (Lynch-Stewart et al. 1999).

The Saskatchewan Watershed Authority is currently developing a new Wetland Conservation and Drainage Management Policy to direct the Authority's work. The primary objectives of this policy development process are to ensure that issues surrounding drainage management and wetland conservation are addressed so as to effectively meet three of the mandated activities of the Authority: to manage drainage in the province; to protect source water and watershed health; and to coordinate the North American Waterfowl Management Plan on behalf of the province. To promote an approach that balances environmental, economic and social interests, the policy development has included ongoing discussions with many interested organizations, including agriculture, industry, and conservation groups, and Aboriginal, local, and federal governments. It is anticipated that over the next six months the Authority will finalize the policy, after a final review by other government agencies and stakeholder organizations.

The Interim Surface Water Quality Objectives (Saskatchewan Environment 1996) have been developed to address general and specific objectives for surface water quality objectives, and general objectives for effluent discharges and effluent mixing zones. General water quality objectives provide a minimum level of protection for general users. Specific water quality objectives pertain to water quality requirements for protecting aquatic life and wildlife, recreational uses, and agricultural uses (crop irrigation and livestock watering). Although the objectives are geared towards surface water quality, they are also applicable to groundwater.

Saskatchewan's Safe Drinking Water Strategy was developed by the Government of Saskatchewan and announced in April 2002. The strategy outlines the province's plan to protect and enhance drinking water quality and supplies in a sustainable manner (http://www.se.gov.sk.ca/environment/protection/water/Water_report_April_2003.pdf).

Legislative Tools, Strategies, Policies, and Guidelines related to Aquatic Fragmentation

The *Navigable Waters Protection Act* and *Regulations*, administered by Transport Canada, regulate the construction of works in navigable waters.

The *Fisheries Act*, administered by Fisheries and Oceans Canada, protects fish habitat through the regulation of impediments to fish migration, the disturbance of fish habitat, and the discharge of deleterious substances in water frequented by fish.

The *Fisheries Regulations*, administered by Fisheries and Oceans Canada under the *Fisheries Act*, promotes the sustainable management of fisheries in Saskatchewan by: administering a licensing program; managing the allocation of fish resources; and controlling aquaculture and the marketing, stocking and importation of fish.

The Policy for the Management of Fish Habitat, developed by Fisheries and Oceans Canada in 1985, applies to habitat that directly or indirectly supports Canada's freshwater and marine fisheries.

The Shore Primer contains guidelines that were developed by Fisheries and Oceans Canada for assisting waterfront residents with the development and management of a healthy waterfront.

Fisheries and Oceans Canada has also developed numerous fact sheets for Saskatchewan related to fish habitat (http://www.dfo-mpo.gc.ca/canwaters-eauxcan/infocentre/guidelines-conseils/index_e.asp).

Legislative Tools, Strategies, Policies, and Guidelines related to Wastewater

The Water Regulations, 2002, administered by Saskatchewan Environment under *The Environmental Management and Protection Act, 2002*, regulates the operations and reporting of municipal water treatment and wastewater treatment facilities.

The Plumbing and Drainage Regulations, administered by Saskatchewan Health through the local health authority, regulates private sewage systems.

Legislative Tools, Strategies, Policies, and Guidelines related to Agriculture

The Agricultural Operations Act, administered by Saskatchewan Agriculture and Food, sets forth regulations for nuisance provisions and intensive livestock provisions.

The Irrigation Act, 1996, administered by Saskatchewan Agriculture and Food, sets out guidelines to promote environmentally-sustainable irrigation in Saskatchewan.

The *Fertilizers Act* and *Regulations* are administered by the Canadian Food Inspection Agency. Some of the activities that the Canadian Food Inspection Agency is involved with include: registration of fertilizers; review of fertilizer product safety, efficacy, and labelling; monitoring for active ingredients and contaminants in the market place; administering the Canadian Fertilizer Quality Assurance Program (CFQAP); and inspection and enforcement.

The Hazardous Substances and Waste Dangerous Goods Regulations, administered by Saskatchewan Environment, control the storage and handling of designated Hazardous Substances and Waste Dangerous Goods and the decommissioning of Hazardous Substances and Waste Dangerous Goods storage facilities.

The Environmental Spill Control Regulations, administered by Saskatchewan Environment, outline the types of spills that these regulations apply to and the procedure that must be followed if a spill occurs, including how the spill must be reported, the remedial action that must be taken, and the disposal of the spilled pollutant.

The Agricultural Policy Framework is an agricultural strategy developed by federal, provincial and territorial Ministers of Agriculture. The policy addresses agriculture and how it relates to: business risk management; the environment; food safety and quality; continuous learning; and science and innovation.

Legislative Tools, Strategies, Policies, and Guidelines related to Oil and Gas

The Mineral Resources Act, 1985 administered by Saskatchewan Industry and Resources, applies to all exploration, development, conservation or management of provincial mineral resources.

The Oil and Gas Conservation Act and *The Oil and Gas Conservation Regulations*, 1985, administered by Saskatchewan Industry and Resources, is designed, in part, to protect the environment and environmentally-sensitive areas with regards to drilling, operations and well abandonment of the oil and gas industry. The Regulations outline when a spill must be reported.

The Seismic Exploration Regulations, 1999, administered by Saskatchewan Industry and Resources, outlines the requirements a company interested in seismic exploration must complete, including: applying for a license to conduct seismic exploration; submitting a preliminary plan of the program for approval prior to commencing field operations; following the restrictions on seismic exploration; restoring property that has been damaged by the seismic exploration activities; and proper handling of explosives. Preliminary proposals for all seismic projects are reviewed by Saskatchewan Environment. Proposals are jointly reviewed by Saskatchewan Environment and Saskatchewan Agriculture and Food if the proposed project affects Crown agricultural land. Saskatchewan Environment uses the following legislation to review the proposal:

- *The Environmental Assessment Act*;
- *The Wildlife Habitat Protection Act*;
- the *Fisheries Act*;
- *The Forest Resources Management Act*;
- *The Provincial Lands Act*;
- *The Environmental Management and Protection Act, 2002*; and
- *The Wildlife Act, 1998.*

The Hazardous Substances and Waste Dangerous Goods Regulations, administered by Saskatchewan Environment, control the storage and handling of designated Hazardous Substances and Waste Dangerous Goods and the decommissioning of Hazardous Substances and Waste Dangerous Goods storage facilities.

The Environmental Spill Control Regulations, administered by Saskatchewan Environment, outline the types of spills that these regulations apply to and the procedure that must be followed if a spill occurs, including how the spill must be reported, the remedial action that must be taken, and the disposal of the spilled pollutant.

The PCB Waste Storage Regulations, administered by Saskatchewan Environment, outline the requirements of how PCBs should be stored and the storage facility requirements.

The Saskatchewan Upstream Petroleum Industry Storage Standards, regulated by Saskatchewan Industry and Resources, outlines environmental protection measures that the industry must abide by to ensure that the storage of materials produced, generated and used by the industry are environmentally sound.

The Guidelines for the Construction and Monitoring of Oily Byproduct Storage Structures, adopted by Saskatchewan Industry and Resources, deals with the environmental considerations that must be incorporated in the construction, operation and maintenance of hydrocarbon-contaminated solid and liquid storage.

The Application of Oily Byproducts to Municipal Roads Guidelines outlines the environmental issues that must be taken into account to ensure the application of this byproduct on roads is done in an environmentally sensitive manner.

The Upstream Waste Management Guidelines, prepared for the Saskatchewan Petroleum Industry – Government Environment Committee (SPIGEC), were designed to minimize the impact of upstream waste material on the environment. The guidelines outline the proper handling, storage, treatment, transport and disposal of industrial waste produced by the upstream oil and gas industry.

The Spill Site Reclamation Guidelines provides operators with a guide to restoration methods that reduce the environmental impact of crude oil, salt water and emulsion spills.

The Upstream Contaminated Sites Remediation and Environmental Site Assessment Guidelines provides a standardized approach to the identification, environmental assessment and remediation of contaminated sites caused by the upstream oil and gas industry.

The Drilling Waste Management and Frac Fluid and Sand Disposal Guidelines pertains to the environmentally appropriate management of drilling waste and Frac fluids and sands.

The Interim Draft Industrial Landfilling Requirements for Wastes Generated from Upstream Oil and Gas Industry deals with reducing and properly handling wastes generated from the upstream oil and gas industry.

Legislative Tools, Strategies, Policies, and Guidelines related to Mining

The Mineral Resources Act, 1985 administered by Saskatchewan Industry and Resources, applies to all exploration, development, conservation or management of provincial mineral resources.

The Mineral Industry Environmental Protection Regulations, 1996, administered by Saskatchewan Environment through *The Environmental Management and Protection Act, 2002*, control the construction, operation, closure and decommissioning of a pollutant control facility. This applies where a pollutant control facility is an area used for the collection, containment, storage, transmission, treatment or disposal of pollutants associated with mining operations or mineral operations.

The *Metal Mining Effluent Regulations and Guidelines*, administered under the *Fisheries Act*, apply to all metal mines, except gold mines using cyanidation, that have been in operation prior to February 1977. "The Regulations impose limits on releases of cyanide, metals, and suspended solids, and prohibit the discharge of effluent that is acutely lethal to fish. The Regulations also require metal mines to conduct Environmental Effects Monitoring programs to identify any adverse effects of their effluent on fish, fish habitat, and the use of fisheries resources" (Canada-Yukon Business Service Centre 2003).

The Seismic Exploration Regulations, 1999, administered by Saskatchewan Industry and Resources, outlines the requirements a company interested in seismic exploration must complete, including: applying for a license to conduct seismic exploration; submitting a preliminary plan of the program for approval prior to commencing field operations; following the restrictions on seismic exploration; restoring property that has been damaged by the seismic exploration activities; and proper handling of explosives. Preliminary proposals for all seismic projects are reviewed by Saskatchewan Environment. Proposals are jointly reviewed by Saskatchewan Environment and Saskatchewan Agriculture and Food if the proposed project affects Crown agricultural land. Saskatchewan Environment uses the following legislation to review the proposal:

- *The Environmental Assessment Act*;
- *The Wildlife Habitat Protection Act*;
- the *Fisheries Act*;
- *The Forest Resources Management Act*;
- *The Provincial Lands Act*;
- *The Environmental Management and Protection Act, 2002*; and
- *The Wildlife Act, 1998*.

To promote best management practices for mineral exploration, the *Mineral Exploration Guidelines for Saskatchewan* were developed. They are intended to be used to "assist government and industry in the application and approval process for mineral exploration activities on land administered by Saskatchewan Environment". These guidelines provide information on best management practices to assist proponents in reducing the environmental impacts of planning, initiating and completing a mineral exploration program (Saskatchewan Mineral Exploration and Government Advisory Committee 2005).

Legislative Tools, Strategies, Policies, and Guidelines related to Forestry

The Forest Resources Management Act, administered by Saskatchewan Environment, promotes the sustainable management of forested lands through, in part, the protection of biodiversity and watersheds. The Act and Regulations regulate Forest Management Agreements and Term Supply Licences.

Saskatchewan Environment is also developing four legislated manuals that will assist in forestry management in Saskatchewan. These manuals include:

- the Forest Planning Manual;
- the Forest Operations Manual;
- the Compliance Manual; and
- the Scaling Manual.

Legislative Tools, Strategies, Policies, and Guidelines related to Landfills

The Environmental Management and Protection Act, 2002, administered by Saskatchewan Environment, regulates landfills in Saskatchewan. This Act regulates and controls the disposal of deleterious substances and activities that are harmful to air, land and water resources.

The Municipal Refuse Management Regulations, administered by Saskatchewan Environment, were created in 1986 specifically for the management of the municipal landfill program. These regulations, in conjunction with *The Environmental Management and Protection Act, 2002*, regulate and permit municipal landfills in Saskatchewan.

The Clean Air Act and *Regulations*, administered by Saskatchewan Environment, regulate and control air emissions through the issuance of permits to operate industrial sources, fuel-burning equipment, and/or incinerators. The Regulations mandate that operators with permits cannot exceed the maximum established air contaminant concentrations and require operators to report accidental discharge of air emissions.

The Hazardous Substances and Waste Dangerous Goods Regulations, administered by Saskatchewan Environment, control the storage and handling of designated Hazardous Substances and Waste Dangerous Goods and the decommissioning of Hazardous Substances and Waste Dangerous Goods storage facilities.

The Litter Control Act and *Regulations*, administered by Saskatchewan Environment, prohibit the act of littering, establishes fees for individuals caught littering, and enables the establishment of recycling depots for designated containers.

The Used Oil Collection Regulations, administered by Saskatchewan Environment, regulate the implementation of a Used Oil Material Recycling Program.

The Waste Paint Management Regulations, administered by Saskatchewan Environment, regulate the implementation of a Paint Recycling Program.

The Scrap Tire Management Regulations, administered by Saskatchewan Environment, regulate the implementation of a Scrap Tire Management Program.

The Waste Electronic Equipment Regulations, administered by Saskatchewan Environment, regulate the implementation of a province-wide e-waste recycling program.

Legislative Tools, Strategies, Policies, and Guidelines related to Industrial Waste

The Clean Air Act and *Regulations*, administered by Saskatchewan Environment, regulate and control air emissions through the issuance of permits to operate industrial sources, fuel-burning equipment, and/or incinerators. The Regulations mandate that operators with permits cannot exceed the maximum established air contaminant concentrations and require operators to report accidental discharge of air emissions.

The Environmental Management and Protection Act, 2002, administered by Saskatchewan Environment, regulates and controls the disposal of deleterious substances and activities that are harmful to air, land and water resources.

The *Fish Toxicant Regulations*, administered by Fisheries and Oceans Canada under the *Fisheries Act*, deal with the discharge of deleterious substances that are fish toxicants.

The *Pulp and Paper Effluent Regulations*, regulated by Environment Canada under the *Fisheries Act*, require pulp and paper mills to conduct an Environmental Effects Monitoring program (EEM). The Environmental Effects Monitoring program consists of a number of monitoring surveys, including:

- *The Fish Survey* (biological monitoring survey);
- *The Benthic Invertebrate Community Survey* (biological monitoring survey);
- *Fish Usability* (biological monitoring survey);
- *Alternative Monitoring Methods*;
- *Sublethal Toxicity Testing*; and
- *Environmental Supporting Variables*.

The *Metal Mining Effluent Regulations*, regulated by Environment Canada under the authority of the *Fisheries Act*, require metal mines to conduct an Environmental Effects Monitoring program (EEM). The Environmental Effects Monitoring program consists of a number of monitoring surveys, including:

- *The Fish Survey* (biological monitoring survey);
- *The Benthic Invertebrate Community Survey* (biological monitoring survey);
- *Fish Usability* (biological monitoring survey);
- *Alternative Monitoring Methods*;
- *Sublethal Toxicity Testing*; and
- *Environmental Supporting Variables*.

Legislative Tools, Strategies, Policies, and Guidelines related to Invasive Species

The Fisheries Act (Saskatchewan), 1994, regulated by Saskatchewan Environment, prohibits the introduction of fish species except in accordance with any licence or any provisions of this Act or the *Fisheries Act* or the *Fisheries Regulations*.

Legislative Tools, Strategies, Policies, and Guidelines related to Species at Risk

The *Species at Risk Act (2002)*, regulated by Environment Canada, addresses the protection, recovery, and management of wildlife species that have been designated as being of special concern.

The Wildlife Act, 1998, regulated by Saskatchewan Environment, addresses the protection of wildlife and wild species at risk in the province of Saskatchewan. Some of the issues covered in the Act include: harvesting, licensing, prohibitions and prosecutions, enforcement, and offences and penalties related to the protection of wildlife and species at risk.

The Wildlife Habitat Protection Act, regulated by Saskatchewan Environment, regulates the protection and management of Crown lands for wildlife habitat purposes.

The Accord for the Protection of Species at Risk, regulated by Environment Canada, was agreed upon in 1996 by Canada's federal, provincial and territorial governments. The accord outlines a national commitment to designate species-at-risk, protect their habitats and develop recovery plans (Environment Canada 2002).

Legislative Tools, Strategies, Policies, and Guidelines related to Environmental Protection

The Conservation Easement Act, administered by Saskatchewan Environment, enables conservation easements to be acquired through agreements between specified grantors and holdees for the purpose of the protection, enhancement and rehabilitation of biodiversity and air, land and water quality.

The Ecological Reserves Act, administered by Saskatchewan Environment, facilitates the protection of unique and representative natural ecosystems by appointing Crown land as an ecological reserve.

The Environmental Assessment Act, administered by Saskatchewan Environment, outlines the environmental assessment and review process any project defined as a "development" must undergo to assess the impact of the development on the environment and to ensure developments in Saskatchewan are sustainable.

The Environmental Management and Protection Act, 2002, administered by Saskatchewan Environment, regulates and controls the disposal of deleterious substances and activities that are harmful to air, land and water resources.

The Litter Control Act, administered by Saskatchewan Environment, prohibits the act of littering, establishes fees for individuals caught littering, and enables the establishment of recycling depots for designated containers.

The Natural Resources Act, administered by Saskatchewan Environment, regulates the planning, construction, operation and management of any parks or renewable natural resources in Saskatchewan.

The Parks Act, administered by Saskatchewan Environment, enables the administration, disposition, establishment and management of parks and park land reserves in Saskatchewan.

SUMMARY

The purpose of the *State of the Watershed Report* is to regularly assess and report on watershed health to ensure source water protection and sufficient water supplies in Saskatchewan. Environmental indicators were developed, based on the *Stress-Condition-Response* Model, to assess the health of watersheds in Saskatchewan. This report is specifically designed to allow watershed health comparisons to be made among watersheds and to provide a baseline for comparisons within watersheds over time.

Condition

To assess the health of watersheds in Saskatchewan, seven condition indicators were developed. Each of the condition indicators have rating schemes that allow for the assessment of watershed health. The health of Saskatchewan's watersheds was categorized into one of three classes: healthy, stressed or impaired. All condition indicators were weighted equally to provide means of assessing overall watershed health. The health of a watershed was determined using the Minimum Operator. The principle of using the Minimum Operator is that the health of the watershed is based on the lowest health rating of all of the seven condition indicators. Therefore, a watershed is rated as impaired if at least one of the seven condition indicators had a rating of impaired; stressed if the lowest rating for at least one of the seven condition indicators was stressed; or healthy if all of the seven condition indicators had a rating of healthy.

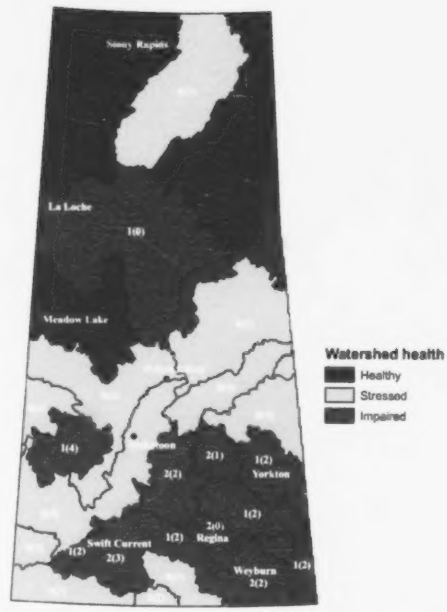


Figure 79. Health of watersheds based on condition indicators.

Note: numbers within the watershed boundaries represent the number of condition indicators that are either impaired or stressed. For example, in the Assiniboine River Watershed there is one impaired condition indicator and two stressed condition indicators, 1(2).

Based on this health assessment, six of Saskatchewan's watersheds were identified as being healthy, eleven watersheds were identified as being stressed, and twelve watersheds were identified as being impaired.

Table 22. Watershed report card for condition indicators.

Watershed	Water quality	Surface water quantity	Riparian**	Permanent cover	Rangeland health	Acid deposition	Health Grade
Assiniboine River	Healthy	Healthy	Stressed	Stressed	Impaired	Healthy	Impaired
Athabasca River		Healthy	Healthy	Healthy		Healthy	Healthy
Battle River	Stressed	Healthy	Stressed	Stressed		Stressed	Stressed
Beaver River	Healthy	Healthy	Healthy	Healthy		Healthy	Healthy
Big Muddy Creek		Healthy	Stressed	Stressed	Stressed	Healthy	Stressed
Black Lake		Healthy	Healthy	Healthy		Stressed	Stressed
Carrot River	Stressed	Healthy	Stressed	Stressed	Stressed	Healthy	Stressed
Churchill River	Healthy	Healthy	Healthy	Healthy		Impaired	Impaired
Cypress Hills North Slope		Stressed	Healthy	Healthy	Stressed	Stressed	Stressed
Eagle Creek		Stressed	Stressed	Impaired	Stressed	Stressed	Impaired
Kasba Lake		Healthy	Healthy	Healthy		Healthy	Healthy
Lake Athabasca		Healthy	Healthy	Healthy		Healthy	Healthy
Lake Winnipegosis	Healthy	Healthy	Stressed	Healthy		Healthy	Stressed
Lower Qu'Appelle River	Stressed	Healthy	Stressed	Impaired		Healthy	Impaired
Lower Souris River	Healthy	Healthy	Stressed	Impaired	Stressed	Healthy	Impaired
Milk River		Stressed	Healthy	Healthy	Stressed	Stressed	Stressed
Moose Jaw River		Healthy	Stressed	Impaired	Stressed	Healthy	Impaired
North Saskatchewan River	Healthy	Healthy	Stressed	Stressed	Stressed	Stressed	Stressed
Old Wives Lake		Impaired	Stressed	Stressed	Stressed	Impaired	Impaired
Poplar River		Healthy	Stressed	Stressed		Healthy	Stressed
Quill Lakes		Healthy	Impaired	Impaired	Stressed	Healthy	Impaired
Reindeer River / Wollaston Lake		Healthy	Healthy	Healthy		Healthy	Healthy
Saskatchewan River	Stressed	Healthy	Healthy	Healthy		Healthy	Stressed
South Saskatchewan River	Stressed	Healthy	Stressed	Stressed	Stressed	Stressed	Stressed
Swift Current Creek		Healthy	Stressed	Stressed		Impaired	Impaired
Tazin River		Healthy	Healthy	Healthy		Healthy	Healthy
Upper Qu'Appelle River	Healthy	Impaired	Stressed	Impaired	Stressed	Healthy	Impaired
Upper Souris River		Impaired	Stressed	Impaired	Stressed	Healthy	Impaired
Wascana Creek		Healthy	Impaired	Impaired		Healthy	Impaired

*Blank cells indicate data are unavailable or not applicable for that watershed.
**The values in the riparian column are an average of the riparian health assessment and riparian buffer indicators.

Table 22. Watershed report card for condition indicators.

Watershed	Water quality	Surface water quantity	Riparian**	Permanent cover	Rangeland health	Acid deposition	Health Grade
Assiniboine River	Healthy	Healthy	Stressed	Stressed	Impaired	Healthy	**Impaired**
Athabasca River		Healthy	Healthy	Healthy		Healthy	**Healthy**
Battle River	Stressed	Healthy	Stressed	Stressed		Stressed	**Stressed**
Beaver River	Healthy	Healthy	Healthy	Healthy		Healthy	**Healthy**
Big Muddy Creek		Healthy	Stressed	Stressed	Stressed	Healthy	**Stressed**
Black Lake		Healthy	Healthy	Healthy		Stressed	**Stressed**
Carrot River	Stressed	Healthy	Stressed	Stressed	Stressed	Healthy	**Stressed**
Churchill River	Healthy	Healthy	Healthy	Healthy		Impaired	**Impaired**
Cypress Hills North Slope		Stressed	Healthy	Healthy	Stressed	Stressed	**Stressed**
Eagle Creek		Stressed	Stressed	Impaired	Stressed	Stressed	**Impaired**
Kasba Lake		Healthy	Healthy	Healthy		Healthy	**Healthy**
Lake Athabasca		Healthy	Healthy	Healthy		Healthy	**Healthy**
Lake Winnipegosis	Healthy	Healthy	Stressed	Healthy		Healthy	**Stressed**
Lower Qu'Appelle River	Stressed	Healthy	Stressed	Impaired		Healthy	**Impaired**
Lower Souris River	Healthy	Healthy	Stressed	Impaired	Stressed	Healthy	**Impaired**
Milk River		Stressed	Healthy	Healthy	Stressed	Stressed	**Stressed**
Moose Jaw River		Healthy	Stressed	Impaired	Stressed	Healthy	**Impaired**
North Saskatchewan River	Healthy	Healthy	Stressed	Stressed	Stressed	Stressed	**Stressed**
Old Wives Lake		Impaired	Stressed	Stressed	Stressed	Impaired	**Impaired**
Poplar River		Healthy	Stressed	Stressed		Healthy	**Stressed**
Quill Lakes		Healthy	Impaired	Impaired	Stressed	Healthy	**Impaired**
Reindeer River / Wollaston Lake		Healthy	Healthy	Healthy		Healthy	**Healthy**
Saskatchewan River	Stressed	Healthy	Healthy	Healthy		Healthy	**Stressed**
South Saskatchewan River	Stressed	Healthy	Stressed	Stressed	Stressed	Stressed	**Stressed**
Swift Current Creek		Healthy	Stressed	Stressed		Impaired	**Impaired**
Tazin River		Healthy	Healthy	Healthy		Healthy	**Healthy**
Upper Qu'Appelle River	Healthy	Impaired	Stressed	Impaired	Stressed	Healthy	**Impaired**
Upper Souris River		Impaired	Stressed	Impaired	Stressed	Healthy	**Impaired**
Wascana Creek		Healthy	Impaired	Impaired		Healthy	**Impaired**

Blank cells indicate data are unavailable or not applicable for that watershed.

*The values in the riparian column are an average of the riparian health assessment and riparian buffer indicators.

Stressors

To assess the potential stress of human activities on watersheds in Saskatchewan, 19 stressor indicators were developed. Each of the stressor indicators have rating schemes that allow stresses to be rated by watershed. The stressors on Saskatchewan's watersheds were categorized into one of three classes: low stress, moderate stress or high stress. All stressor indicators were weighted equally to provide means of assessing the overall stress on each watershed. The overall stress of a watershed was determined using the Jenks' Optimization method. The Jenks' Optimization method resulted in the following rating scheme:

- Low stress – less than 3 out of the 19 stressor indicators have a high stress rating
- Moderate stress – between 3 and 5 out of the 19 stressor indicators have a high stress rating
- High stress – more than 5 out of the 19 stressor indicators have a high stress rating

Figure 80. Stress rating by watershed.

Based on the ratings for the 19 stressor indicators, four watersheds have a high stress rating, 12 watersheds have a moderate stress rating and 13 watersheds have a low stress rating.

Table 23. Watershed report card for stressor indicators.

Watershed	Human population	Roads	Surface water allocation	Groundwater allocation	Aquatic fragmentation	Potential runoff from impervious areas	Wastewater effluent discharge	Livestock	Soil erosion	Fertilizer inputs
Assiniboine River	Low stress	High stress	Low stress	Moderate stress	High stress	Moderate stress	Moderate stress	High stress	Low stress	High stress
Athabasca River	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Low stress		Low stress
Battle River	Low stress	High stress	Low stress	Moderate stress	High stress		Low stress	Moderate stress	Low stress	Moderate stress
Beaver River	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Moderate stress		Low stress
Big Muddy Creek	Low stress	High stress	Low stress	Low stress	Moderate stress		Low stress	Low stress	Low stress	Moderate stress
Black Lake	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Low stress		Low stress
Carrot River	Low stress	Moderate stress	Low stress	Low stress	Moderate stress		Low stress	Low stress		High stress
Churchill River	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Low stress		Low stress
Cypress Hills North Slope	Low stress	Moderate stress	High stress	Low stress	Moderate stress		Low stress	Moderate stress	Low stress	Low stress
Eagle Creek	Low stress	High stress	High stress	Moderate stress	High stress		Moderate stress	Low stress	Low stress	Moderate stress
Kasba Lake	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Low stress		Low stress
Lake Athabasca	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Low stress		Low stress
Lake Winnipegosis	Low stress	Moderate stress	Low stress	Low stress	Moderate stress	Moderate stress	Low stress	Moderate stress	Low stress	Moderate stress
Lower Qu'Appelle River	Low stress	High stress	Moderate stress	Moderate stress	High stress	Low stress	Moderate stress	Moderate stress	Low stress	High stress
Lower Souris River	Low stress	High stress	Low stress	Low stress	High stress		Low stress	Moderate stress	Low stress	Moderate stress
Milk River	Low stress	Moderate stress	High stress	Low stress	Moderate stress		Low stress	Moderate stress	Low stress	Low stress
Moose Jaw River	Moderate stress	High stress	Moderate stress	Low stress	High stress	Low stress	Moderate stress	Low stress	Low stress	Moderate stress
North Sask. River	High stress	High stress	Low stress	High stress	Moderate stress	Low stress	Low stress	High stress	Low stress	Moderate stress
Old Wives Lake	Low stress	High stress	High stress	Low stress	High stress		Low stress	Moderate stress	Low stress	Moderate stress
Poplar River	Low stress	Moderate stress	Low stress	Moderate stress	Moderate stress		Low stress	Moderate stress	Low stress	Low stress
Quill Lakes	Low stress	High stress	Low stress	Low stress	High stress		Low stress	Moderate stress	Low stress	High stress
Reindeer River/ Wollaston Lake	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Low stress		Low stress
Saskatchewan River	Low stress	Low stress	Low stress	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress
South Sask. River	High stress	High stress	Moderate stress	High stress	High stress	Moderate stress	Low stress	Moderate stress	Low stress	Moderate stress
Swift Current Creek	Low stress	High stress	High stress	Low stress	High stress	Moderate stress	Moderate stress	Moderate stress	Low stress	Moderate stress
Tazin River	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Low stress		Low stress
Upper Qu'Appelle River	Low stress	High stress	High stress	High stress	High stress	Low stress	Moderate stress	Low stress	Low stress	High stress
Upper Souris River	Low stress	High stress	High stress	High stress	High stress	High stress	Moderate stress	Low stress	Low stress	Moderate stress
Wascana Creek	Moderate stress	High stress	Low stress	Moderate stress	High stress	High stress	High stress	Low stress	Low stress	High stress

[illegible]

Pesticide inputs	Manure application	Oil and gas spills	Mines	Forestry	Landfills	Contaminated sites	Industrial waste	Wetland loss	Stress Grade	Watershed
Moderate stress	High stress	Low stress	Low stress	High stress	High stress	Low stress	Low stress	Moderate stress	High stress	Assiniboine River
Low stress		Low stress	Low stress	Low stress		Low stress	Low stress		Low stress	Athabasca River
Moderate stress	High stress	High stress	Low stress		Moderate stress	Low stress	Low stress	Moderate stress	Moderate stress	Battle River
Low stress	Low stress	Low stress	Low stress	Moderate stress	Moderate stress	Moderate stress	Low stress		Low stress	Beaver River
Moderate stress	Moderate stress	Low stress	High stress		Moderate stress	Moderate stress	Low stress	Low stress	Low stress	Big Muddy Creek
Low stress		Low stress	Low stress			Low stress	Low stress		Low stress	Black Lake
Moderate stress	Moderate stress	Low stress	Low stress	High stress	Moderate stress	Low stress	Low stress	High stress	Moderate stress	Carrot River
Low stress		Low stress	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Churchill River
Low stress	Moderate stress	Low stress	Low stress	Low stress	Low stress	High stress	Moderate stress	Low stress	Low stress	Cypress Hills North Slope
Moderate stress	Moderate stress	Moderate stress	Low stress		Moderate stress	Moderate stress	Low stress	High stress	Moderate stress	Eagle Creek
Low stress	Moderate stress	Low stress	Low stress			Low stress	Low stress		Low stress	Kasba Lake
Low stress		Low stress	Low stress			Moderate stress	Low stress		Low stress	Lake Athabasca
Low stress	Low stress	Low stress	Low stress	High stress	Moderate stress	Low stress	Low stress	Moderate stress	Low stress	Lake Winnipegosis
Moderate stress	High stress	Low stress	Low stress		High stress	Moderate stress	Low stress	Low stress	Moderate stress	Lower Qu'Appelle River
Moderate stress	High stress	High stress	Low stress	Low stress	Moderate stress	Low stress	Low stress	Low stress	Moderate stress	Lower Souris River
Low stress	Low stress	Low stress	Moderate stress	Low stress	Low stress	Moderate stress	Low stress	Low stress	Low stress	Milk River
Moderate stress	Moderate stress	Low stress	Low stress		Moderate stress	High stress	Low stress	Low stress	Moderate stress	Moose Jaw River
Moderate stress	High stress	Moderate stress	Low stress	Moderate stress	Low stress	Low stress	Low stress	Low stress	Moderate stress	North Sask. River
Moderate stress	Moderate stress	Low stress	Moderate stress		Moderate stress	Moderate stress	Low stress	High stress	Moderate stress	Old Wives Lake
Low stress	High stress	Low stress	High stress		Moderate stress	High stress	Moderate stress	Low stress	Moderate stress	Poplar River
High stress	High stress	Low stress	Low stress		Moderate stress	Low stress	Low stress	Moderate stress	Moderate stress	Quill Lakes
Low stress		Low stress	Low stress			Low stress	Low stress		Low stress	Reindeer River/ Wollaston Lake
Low stress	Low stress	Low stress	Low stress	Moderate stress	Low stress	Low stress	Low stress	Low stress	Low stress	Saskatchewan River
Moderate stress	High stress	Moderate stress	Low stress	Low stress	Moderate stress	Moderate stress	Low stress	Moderate stress	Moderate stress	South Sask. River
Moderate stress	Moderate stress	Moderate stress	Low stress		Moderate stress	Low stress	Low stress	High stress	Moderate stress	Swift Current Creek
Low stress		Low stress	Low stress			Low stress	Low stress		Low stress	Tazin River
High stress	High stress	Low stress	Low stress		High stress	Moderate stress	Low stress	Low stress	High stress	Upper Qu'Appelle River
Moderate stress	High stress	High stress	High stress	Low stress	Moderate stress	Moderate stress	High stress	High stress	High stress	Upper Souris River
High stress	Moderate stress	Low stress	Low stress		Moderate stress	Moderate stress	High stress	Moderate stress	High stress	Wascana Creek

* Blank cells indicate data are unavailable or not applicable for that watershed.

Table 23. Watershed report card for stressor indicators.

Watershed	Human population	Roads	Surface water allocation	Groundwater allocation	Aquatic fragmentation	Potential runoff from impervious areas	Wastewater effluent discharge	Livestock	Soil erosion	Fertilizer inputs
Assiniboine River	Low stress	High stress	Low stress		High stress			High stress	Low stress	High stress
Athabasca River	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Low stress		Low stress
Battle River	Low stress	High stress	Low stress		High stress		Low stress		Low stress	
Beaver River	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress			Low stress
Big Muddy Creek	Low stress	High stress	Low stress	Low stress			Low stress	Low stress	Low stress	
Black Lake	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Low stress		Low stress
Carrot River	Low stress		Low stress	Low stress			Low stress	Low stress		High stress
Churchill River	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Low stress		Low stress
Cypress Hills North Slope	Low stress		High stress	Low stress			Low stress		Low stress	Low stress
Eagle Creek	Low stress	High stress	High stress		High stress			Low stress	Low stress	
Kasba Lake	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Low stress		Low stress
Lake Athabasca	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Low stress		Low stress
Lake Winnipegosis	Low stress		Low stress	Low stress			Low stress		Low stress	
Lower Qu'Appelle River	Low stress	High stress			High stress	Low stress			Low stress	High stress
Lower Souris River	Low stress	High stress	Low stress	Low stress	High stress		Low stress		Low stress	
Milk River	Low stress		High stress	Low stress			Low stress		Low stress	Low stress
Moose Jaw River		High stress		Low stress	High stress	Low stress		Low stress	Low stress	
North Sask. River	High stress	High stress	Low stress	High stress		Low stress	Low stress	High stress	Low stress	
Old Wives Lake	Low stress	High stress	High stress	Low stress	High stress		Low stress		Low stress	
Poplar River	Low stress		Low stress				Low stress		Low stress	Low stress
Quill Lakes	Low stress	High stress	Low stress	Low stress	High stress		Low stress		Low stress	High stress
Reindeer River/ Wollaston Lake	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Low stress		Low stress
Saskatchewan River	Low stress	Low stress	Low stress	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress
South Sask. River	High stress	High stress		High stress	High stress		Low stress		Low stress	
Swift Current Creek	Low stress	High stress	High stress	Low stress	High stress				Low stress	
Tazin River	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Low stress		Low stress
Upper Qu'Appelle River	Low stress	High stress	High stress	High stress	High stress	Low stress		Low stress	Low stress	High stress
Upper Souris River	Low stress	High stress	High stress	High stress	High stress	High stress		Low stress	Low stress	
Wascana Creek		High stress	Low stress		High stress	High stress	High stress	Low stress	Low stress	High stress

* Blank cells indicate data are unavailable or not applicable for that watershed.

Pesticide inputs	Manure application	Oil and gas spills	Mines	Forestry	Landfills	Contaminated sites	Industrial waste	Wetland loss	Stress Grade	Watershed
	High stress	Low stress	Low stress	High stress	High stress	Low stress	Low stress		High stress	Assiniboine River
Low stress		Low stress	Low stress	Low stress		Low stress	Low stress		Low stress	Athabasca River
	High stress	High stress	Low stress			Low stress	Low stress		Moderate stress	Battle River
Low stress	Low stress	Low stress	Low stress				Low stress		Low stress	Beaver River
		Low stress	High stress				Low stress	Low stress	Low stress	Big Muddy Creek
Low stress		Low stress	Low stress			Low stress	Low stress		Low stress	Black Lake
		Low stress	Low stress	High stress		Low stress	Low stress	High stress	Moderate stress	Carrot River
Low stress		Low stress	Low stress	Low stress	Low stress	Low stress	Low stress		Low stress	Churchill River
Low stress		Low stress	Low stress	Low stress	Low stress	High stress		Low stress	Low stress	Cypress Hills North Slope
			Low stress				Low stress	High stress	Moderate stress	Eagle Creek
Low stress		Low stress	Low stress			Low stress	Low stress		Low stress	Kasba Lake
Low stress		Low stress	Low stress				Low stress		Low stress	Lake Athabasca
Low stress	Low stress	Low stress	Low stress	High stress		Low stress	Low stress		Low stress	Lake Winnipegosis
	High stress	Low stress	Low stress		High stress		Low stress	Low stress	Moderate stress	Lower Qu'Appelle River
	High stress	High stress	Low stress	Low stress		Low stress	Low stress	Low stress	Moderate stress	Lower Souris River
Low stress	Low stress	Low stress		Low stress	Low stress		Low stress	Low stress	Low stress	Milk River
		Low stress	Low stress			High stress	Low stress	Low stress	Moderate stress	Moose Jaw River
	High stress		Low stress		Low stress	Low stress	Low stress	Low stress	Moderate stress	North Sask. River
		Low stress					Low stress	High stress	Moderate stress	Old Wives Lake
Low stress	High stress	Low stress	High stress			High stress		Low stress	Moderate stress	Poplar River
High stress	High stress	Low stress	Low stress			Low stress	Low stress		Moderate stress	Quill Lakes
Low stress		Low stress	Low stress			Low stress	Low stress		Low stress	Reindeer River/ Wollaston Lake
Low stress	Low stress	Low stress	Low stress		Low stress	Low stress	Low stress	Low stress	Low stress	Saskatchewan River
	High stress		Low stress	Low stress			Low stress		Moderate stress	South Sask. River
			Low stress			Low stress	Low stress	High stress	Moderate stress	Swift Current Creek
Low stress		Low stress	Low stress			Low stress	Low stress		Low stress	Tazin River
High stress	High stress	Low stress	Low stress		High stress		Low stress	Low stress	High stress	Upper Qu'Appelle River
	High stress	High stress	High stress	Low stress			High stress	High stress	High stress	Upper Souris River
High stress		Low stress	Low stress				High stress		High stress	Wascana Creek

* Black cells indicate data are unavailable or not applicable for that watershed.

Responses

Ten response indicators have been developed to provide information on management decisions that have been made to mitigate the stressors and improve the health of Saskatchewan's watersheds. Five of the ten response indicators have insufficient data to rate the management responses within or between watersheds. Organizations typically collect management response information on a province-wide scale, preventing the summarization of information by watershed. The five indicators that have sufficient data by watershed include the conservation stewards, watershed and land use planning, water quality monitoring, water quantity monitoring, and protected areas indicators.

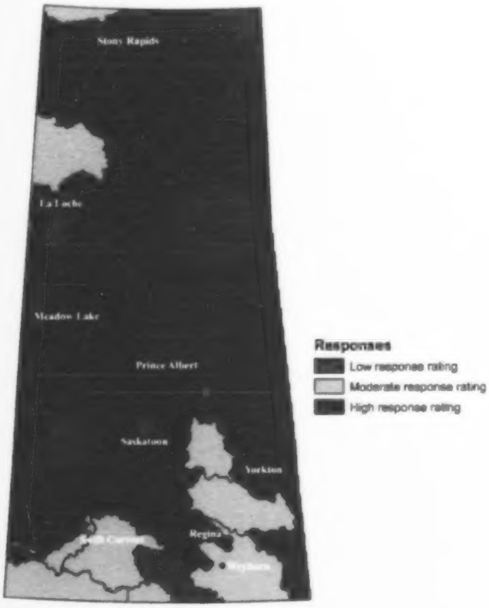


Figure 81. Response rating by watershed.

Of the 29 watersheds, three have a low response rate, nine have a moderate response rate and 17 have a high response rate. The watersheds with the lowest response rate include the Big Muddy Creek, Eagle Creek, and Kasba Lake Watersheds.

The condition of all southern Saskatchewan watersheds ranked as either stressed or impaired. The Black Lake and Churchill River Watersheds were the only two watersheds in northern Saskatchewan not ranked as being healthy. The reason for lower health ratings in these two watersheds is because of acid rain deposition. The majority of the southern watersheds had either moderate or high stress potentials, with the exception of the Big Muddy Creek, Cypress Hills North Slope, Milk River, and Lake Winnipegosis Watersheds. The northern watersheds all had low stress potential. The Lower Qu'Appelle River, Upper Souris River, and Wascana Creek Watersheds all had an impaired health rating and high stress potential; however, they had a moderate response rating. Response ratings in northern watersheds were typically moderate to low. However, since they all have low stress potential and the condition of the watersheds are typically healthy, there is no need at present to have a high response rate.

Table 24. Watershed report card for response indicators.

Watershed	Conservation stewards	Watershed and land use planning	Water quality monitoring and management	Water quantity monitoring and management	Protected areas	Response Rate
Assiniboine River	Present	Present	Present	Present	Less than	**High**
Athabasca River		Absent	Absent	Present	Achieved	Moderate
Battle River	Present	Present	Present	Present	Less than	**High**
Beaver River	Present	Present	Present	Present	Achieved	**High**
Big Muddy Creek	Present	Absent	Absent	Absent	Less than	**Low**
Black Lake		Present	Present	Present	Less than	**High**
Carrot River	Present	Present	Present	Present	Less than	**High**
Churchill River	Present	Present	Present	Present	Less than	**High**
Cypress Hills North Slope	Present	Present	Present	Present	Achieved	**High**
Eagle Creek	Present	Absent	Absent	Present	Less than	**Low**
Kasba Lake		Absent	Absent	Absent	Achieved	**Low**
Lake Athabasca		Present	Present	Present	Less than	**High**
Lake Winnipegosis	Present	Present	Present	Present	Less than	**High**
Lower Qu'Appelle River	Present	Absent	Present	Present	Less than	Moderate
Lower Souris River	Present	Present	Present	Present	Less than	**High**
Milk River	Present	Absent	Absent	Present	Achieved	Moderate
Moose Jaw River	Present	Present	Present	Present	Less than	**High**
North Saskatchewan River	Present	Present	Present	Present	Achieved	**High**
Old Wives Lake	Present	Absent	Present	Present	Less than	Moderate
Poplar River	Present	Absent	Present	Present	Less than	Moderate
Quill Lakes	Present	Absent	Present	Present	Less than	Moderate
Reindeer River / Wollaston Lake		Present	Present	Present	Less than	**High**
Saskatchewan River	Present	Present	Present	Present	Less than	**High**
South Saskatchewan River	Present	Present	Present	Present	Achieved	**High**
Swift Current Creek	Present	Absent	Present	Present	Less than	Moderate
Tazin River		Absent	Absent	Present	Achieved	Moderate
Upper Qu'Appelle River	Present	Present	Present	Present	Less than	**High**
Upper Souris River	Present	Absent	Present	Present	Less than	Moderate
Wascana Creek	Present	Present	Absent	Present	Less than	Moderate

*Blank cells indicate data are unavailable or not applicable for that watershed.

Table 24. Watershed report card for response indicators.

Watershed	Conservation stewards	Watershed and land use planning	Water quality monitoring and management	Water quantity monitoring and management	Protected areas	Response Rate
Assiniboine River	Present	Present	Present	Present	Less than	High
Athabasca River		Absent	Absent	Present	Achieved	Moderate
Battle River	Present	Present	Present	Present	Less than	High
Beaver River	Present	Present	Present	Present	Achieved	High
Big Muddy Creek	Present	Absent	Absent	Absent	Less than	Low
Black Lake		Present	Present	Present	Less than	High
Carrot River	Present	Present	Present	Present	Less than	High
Churchill River	Present	Present	Present	Present	Less than	High
Cypress Hills North Slope	Present	Present	Present	Present	Achieved	High
Eagle Creek	Present	Absent	Absent	Present	Less than	Low
Kasba Lake		Absent	Absent	Absent	Achieved	Low
Lake Athabasca		Present	Present	Present	Less than	High
Lake Winnipegosis	Present	Present	Present	Present	Less than	High
Lower Qu'Appelle River	Present	Absent	Present	Present	Less than	Moderate
Lower Souris River	Present	Present	Present	Present	Less than	High
Milk River	Present	Absent	Absent	Present	Achieved	Moderate
Moose Jaw River	Present	Present	Present	Present	Less than	High
North Saskatchewan River	Present	Present	Present	Present	Achieved	High
Old Wives Lake	Present	Absent	Present	Present	Less than	Moderate
Poplar River	Present	Absent	Present	Present	Less than	Moderate
Quill Lakes	Present	Absent	Present	Present	Less than	Moderate
Reindeer River / Wollaston Lake		Present	Present	Present	Less than	High
Saskatchewan River	Present	Present	Present	Present	Less than	High
South Saskatchewan River	Present	Present	Present	Present	Achieved	High
Swift Current Creek	Present	Absent	Present	Present	Less than	Moderate
Tazin River		Absent	Absent	Present	Achieved	Moderate
Upper Qu'Appelle River	Present	Present	Present	Present	Less than	High
Upper Souris River	Present	Absent	Present	Present	Less than	Moderate
Wascana Creek	Present	Present	Absent	Present	Less than	Moderate

*Blank cells indicate data are unavailable or not applicable for that watershed.

The condition of all southern Saskatchewan watersheds ranked as either stressed or impaired. The Black Lake and Churchill River Watersheds were the only two watersheds in northern Saskatchewan not ranked as being healthy. The reason for lower health ratings in these two watersheds is because of acid rain deposition. The majority of the southern watersheds had either moderate or high stress potentials, with the exception of the Big Muddy Creek, Cypress Hills North Slope, Milk River, and Lake Winnipegosis Watersheds. The northern watersheds all had low stress potential. Response ratings in northern watersheds were typically moderate to low. However, since they all have low stress potential and the condition of the watersheds are typically healthy, there is no need at present to have a high response rate.

Appendix 1. Spatial Weighting

All the information in this document is presented by watershed. However, the source information is often tabulated by some other area unit, e.g. Consolidated Census Sub-Division (CCS) for the Census of Agriculture data, as shown below in Figure 82a. Converting information to the watershed level is accomplished by weighting the source information according to the area that the source area unit occupies of a given watershed. E.g. to calculate the head of cattle per watershed, the head of cattle in each CCS is multiplied by the fractional area of the watershed(s) it occupies, as shown in Figure 82b.

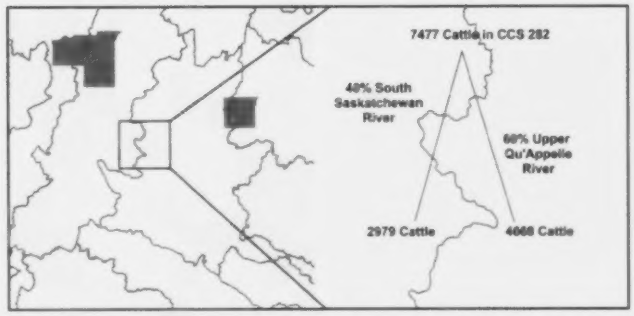


Figure 82. a) Watershed and CCS boundaries; b) Fractional area of CCS by watershed.

All CCS' are then summed over each watershed to yield an estimate of the number of cattle per watershed, according to (9).

$$b_{xi} = \sum_{k=1}^{k} \rho_{xk} \times \nu_{ki} \quad (9)$$

Where: b_{xi} is the score for watershed x on indicator i, e.g. head of cattle

ρ_{xk} is the proportion of source area unit k, e.g. CCS, in watershed x

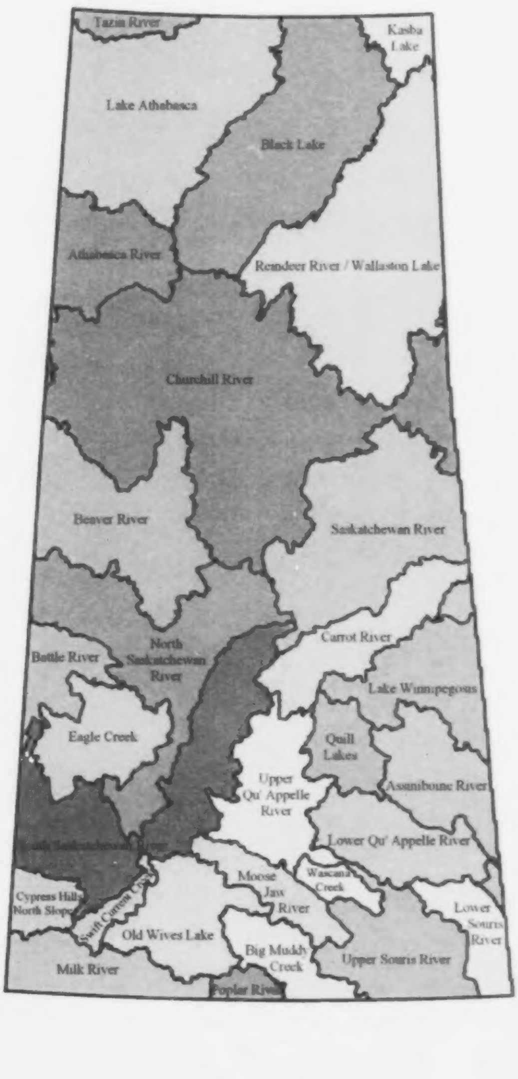
ν_{ki} is the value of indicator i in source area unit k

This method assumes that the source phenomenon is equally distributed across the watershed. This assumption is violated to varying degrees, but the method is certainly sound enough for the purposes of this exercise, which are coarse-level and intended only to intelligently maintain dispersion over a gradient.

Appendix 2: Basin Multipliers

Appendix 3. Saskatchewan Watersheds

Appendix 3. Saskatchewan Watersheds



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GLOSSARY OF TERMS

Animal Unit Equivalent (AUE): A live weight of 455 kilograms (1,000 lbs.) of livestock or any combination of livestock, poultry and farmed game that equals 455 kilograms. AUEs allow standardized waste and manure impact assessment across animal species. *Stocking Rate* and *Carrying Capacity* are expressed in **Animal Unit Month** (AUM), which is the amount of forage required by one Animal Unit in one month.

Aquatic Habitat Fragmentation: Breaks in habitat, ecosystems or land use types into smaller fragments. Fragmentation results from natural causes such as beaver dams, or from man-made control structures.

Aquifer: A geologic formation which contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Biodiversity: The variety of plant and animal life in the world or in a particular habitat. Biodiversity can be described as all species of living organisms and their supporting ecosystems and ecological processes. Typically biodiversity is discussed at three levels: species, genetic and ecosystem diversity.

Cubic Decametre: 1 dam^3 = 1000 cubic metres (1000 m^3) = 1 million litres.

Ecosystem: The interaction of living organisms with each other and their environment as a single functioning unit.

Eutrophication: The nutrient enrichment of a waterbody, stimulating excessive algal blooms and aquatic plant growth. Decaying plant matter reduces dissolved oxygen, which can cause other aquatic organisms to die.

GIS (Geographical Information Systems): A computer software tool for capturing, storing, integrating, manipulating, analysing and displaying data related to positions on the Earth's surface. Data might be represented as several different layers where each layer holds data about a particular kind of feature (e.g. roads).

Gross Watershed or Incremental Gross Drainage Basin: The effective and non-effective drainage area for a hydrometric gauging station.

Gross Water Availability: The total amount of water available for development along a stream or within a watershed without accounting for existing or proposed internal water allocations. It is multiplied by either one-half or the full annual unit runoff, depending on downstream allocations. The multiplier is one-half if the watershed is part of an international basin (e.g. Souris River) or interprovincial basin (e.g. Assiniboine River).

Groundwater: All subsurface water distinct from surface water, specifically within the saturated zone of a defined aquifer.

Hydrology: The study of the storage and movement of water on and below the earth's surface and within the atmosphere.

Intensive Livestock Operation: The confining of one animal unit to less than 370 square metres (or 4,000 square feet).

Instream Flow/Environmental Flow: The amount of water flowing through a stream course that is needed to achieve environmental management objectives.

Land cover: Habitat or vegetation class type (e.g. forest or grassland).

Land use: How humans use an area. Land cover and land use are related, but not equivalent terms.

Net Water Availability: The gross water availability minus the surface water allocations. Net water availability is typically expressed in cubic decametres.

Non-Effective Drainage Area or Areas of Non-contributing Drainage: Non-contributing areas do not contribute to downstream accumulations of stream flow for a median (1:2) annual runoff.

Non-Point Source Pollution: Non-point source pollution comes from many diffuse sources. Transported in runoff, pollutants are deposited into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water. Common pollutants include: fertilizers (nutrients), herbicides, and insecticides from agricultural lands and residential areas; petrochemicals from urban runoff and energy production; sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks; salt from irrigation practices and winter road salting; acid drainage from abandoned mines; bacteria, nutrients and faulty septic systems.

Point Source Pollution: Pollution originating from a single location or source such as pulp effluent, wastewater effluent or an oil spill.

Response Indicators: Represent the management plans implemented to improve the state of the watershed. These are measured by how effective the plan was in improving the state of the watershed.

Riparian Areas: Transition zones between land and water environments. They are narrow strips of land along streams, lakes, potholes, springs, coulees, wooded draws, or anywhere water is plentiful. Riparian areas are defined by vegetation that is different than that upland while providing a unique role socially, economically and ecologically.

Range Site: "an area of rangeland which has the potential to produce and sustain distinctive kinds and amounts of vegetation to result in a characteristic plant community under its particular combination of environmental factors, particularly climate, soils, and associated native biota" (Jacoby 1989).

Stewardship: Caring for land and associated resources and maintaining healthy ecosystems for future generations.

Unit Net Water Availability: The net water availability divided by the basin area. Unit net water availability is typically expressed in millimetres of unit runoff, which is equivalent to dam^3/km^2.

$$\text{Unit runoff} = \frac{\text{Annual volume } (dam^3)}{\text{Effective drainage area } (km^2)}$$

Upland: An area of land that lies above the floodplain. It is characterized by vegetation that relies on precipitation for its water source.

Watershed: A geographic area defined by topographic elevation divides that has a common outlet for its surface runoff.

Watershed Health: A healthy watershed can provide desired maintenance, integrity and ecological processes.

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